AD-A041 354 LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY COORDINA--ETC F/G 8/6

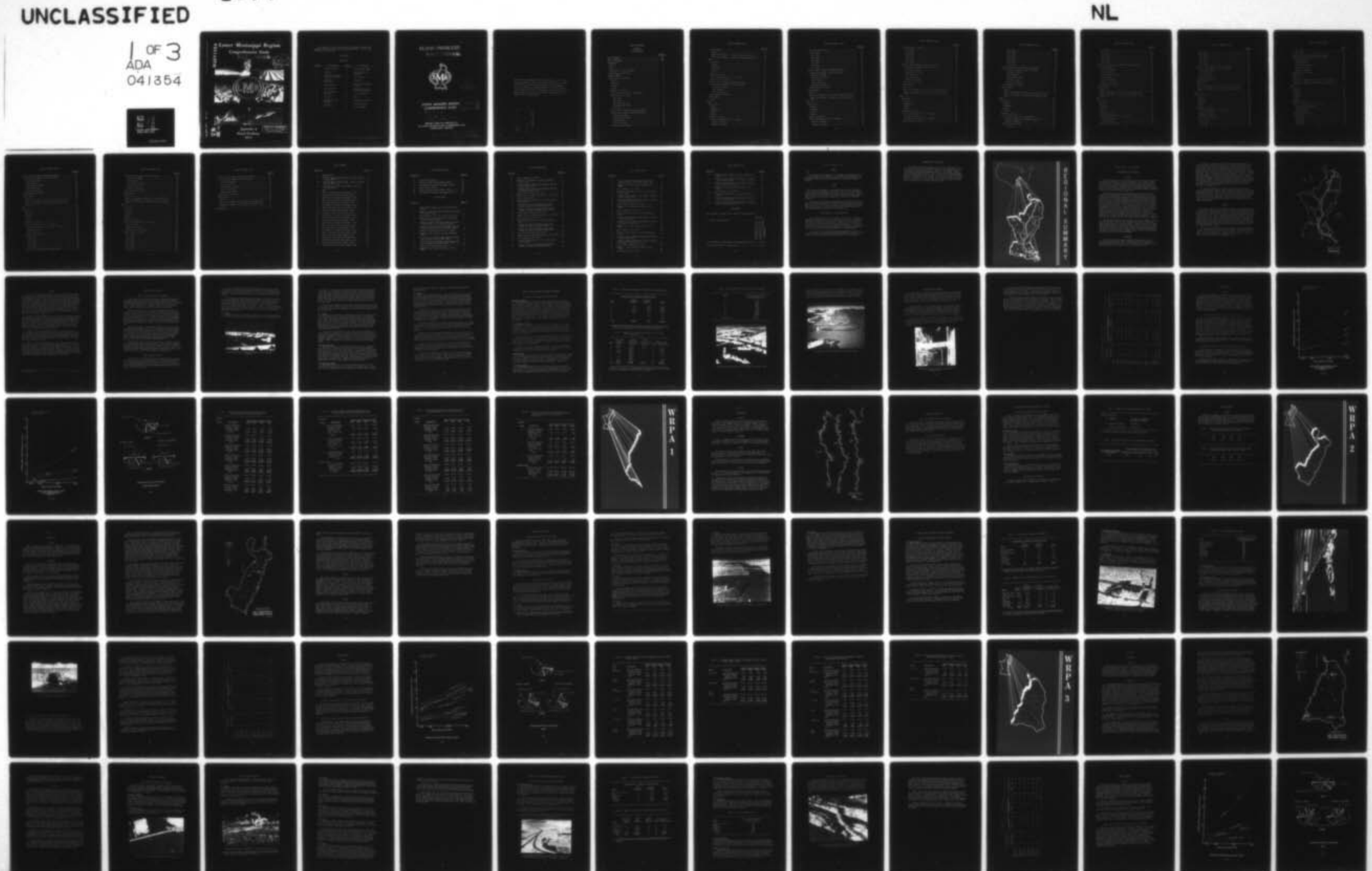
LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY. APPENDIX E. FLOOD--ETC(U)

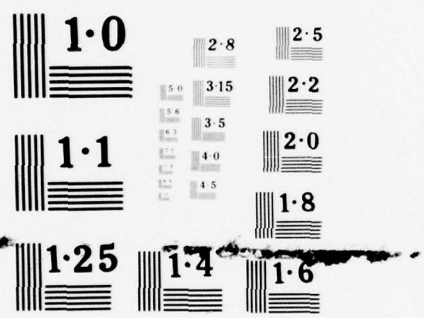
1974

UNCLASSIFIED NL

1 OF 3

ADA 041354

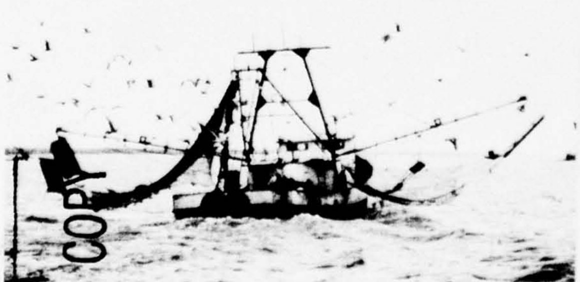




NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

Lower Mississippi Region

Comprehensive Study



Appendix E
Flood Problems
1974

Lower Mississippi Region Comprehensive Study

APPENDIX E FLOOD PROBLEMS

This appendix is one of a series of 22 documents comprising the complete Lower Mississippi Region Comprehensive Study. A list of the documents is shown below.

Main Report

Appendixes

Appendix	Description	Appendix	Description
A	History of Study	K	M and I Water Supply
B	Economics	L	Water Quality and Pollution
C	Regional Climatology, Hydrology & Geology	M	Health Aspects
D	Inventory of Facilities	N	Recreation
E	Flood Problems	O	Coastal and Estuarine Resources
F	Land Resources	P	Archeological and Historical Resources
G	Related Mineral Resources	Q	Fish and Wildlife
H	Irrigation	R	Power
I	Agricultural Land Drainage	S	Sediment and Erosion
J	Navigation	T	Plan Formulation
		U	The Environment

FLOOD PROBLEMS

ORIGINAL CONTAINS COLOR PLATES: ALL DDC
REPRODUCTIONS WILL BE IN BLACK AND WHITE

LMR

(11) 1974

(12) 254 p.

(6) LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY.
Appendix E.
Flood Problems.

PREPARED UNDER THE SUPERVISION OF
THE LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY
COORDINATING COMMITTEE

410 262

This report was prepared at field level by the Lower Mississippi Region Comprehensive Study Coordinating Committee and is subject to review by interested Federal agencies at the departmental level, by Governors of the affected States, and by the Water Resources Council prior to its transmittal to the President of the United States for his review and ultimate transmittal to the Congress for its consideration.

TABLE OF CONTENTS

APPENDIX E

FLOOD PROBLEMS

	Page No.
List of Figures	xii
List of Tables	xiii
List of Photographs	xvi
INTRODUCTION	1
Purpose	1
Scope	1
Relationship to Other Appendixes	1
Presentation of Materials	2
REGIONAL SUMMARY	3
Description of the Region	3
General	3
Topography	3
Climate	4
Economy	6
Flooding in the Region	7
Types and Characteristics of Flooding	7
Major Historical Floods	7
1927 Flood	8
1937 Flood	9
1965 Hurricane Betsy	9
1969 Hurricane Camille	9
1973 Flood	10
Present Control Program and Remaining Damages	11
Existing Flood Damage Prevention Program	11
Structural Program	11
Nonstructural Program	11
Land Treatment	11
Flood Forecasting	11
Remaining Flood Problems	15

TABLE OF CONTENTS (Cont)

	Page No.
Future Damages	18
General	18
Future Flood Damages - National Income Growth Rate	18
Future Flood Damages - Regional Development Growth Rate	18
WRPA 1	27
Description	27
General	27
Topography	27
Climate	27
Economy	27
Flooding in the Area	29
Types and Characteristics of Flooding	29
Major Historical Floods	29
Present Control Program and Remaining Damages	30
Existing Flood Damage Prevention Program	30
Structural Program	30
Land Treatment	30
Flood Forecasting	30
Remaining Flood Problems	30
Future Damages	32
General	32
WRPA 2	33
Description	33
General	33
Topography	33
Climate	36
Economy	36
Flooding in the Area	38
Types and Characteristics of Flooding	38
Backwater Flooding	38
Headwater Flooding	38

TABLE OF CONTENTS (Cont)

	Page No.
Major Historical Floods	38
1927 Flood	38
1937 Flood	39
1945 Flood	39
1950 Flood	39
1957 Flood	39
1972 Flood	40
1973 Flood	41
Present Control Program and Remaining Damages	42
Existing Flood Damage Prevention Program	42
Structural Program	42
Nonstructural Program	44
Land Treatment	44
Flood Forecasting	45
Emergency Operations	45
Remaining Flood Problems	45
Future Damages	50
General	50
Future Flood Damages with National Income Growth Rate	50
Future Flood Damages with Regional Development Growth Rate	50
WRPA 3	57
Description	57
General	57
Topography	57
Climate	58
Economy	60
Flooding in the Area	61
Types and Characteristics of Flooding	61
Backwater Flooding	61
Headwater Flooding	61

TABLE OF CONTENTS (Cont)

	Page No.
Major Historical Floods	62
1927 Flood	62
1937 Flood	63
1945 Flood	63
1950 Flood	63
1957 Flood	63
1973 Flood	63
Present Control Program and Remaining Damages	65
Existing Flood Damage Prevention Program	65
Structural Program	65
Nonstructural Program	67
Land Treatment	67
Flood Forecasting	67
Emergency Operations	67
Remaining Flood Problems	68
Future Damages	71
General	71
Future Flood Damages with National Income Growth Rate	71
Future Flood Damages with Regional Development Growth Rate	75
WRPA 4	77
Description	77
General	77
Topography	77
Climate	80
Economy	80
Flooding in the Area	82
Types and Characteristics of Flooding	82
Headwater Flooding	82
Mississippi River Backwater Flooding	82
Major Historical Floods	82

TABLE OF CONTENTS (Cont)

	Page No.
1927 Flood	82
1932 Flood	83
1937 Flood	83
1948 Flood	83
1961 Flood	83
1969 Flood	84
1973 Flood	84
Present Control Program and Remaining Damages	88
Existing Flood Damage Prevention Program	88
Structural Program	88
Land Treatment	90
Nonstructural Program	91
Flood Forecasting	91
Emergency Operations	91
Remaining Flood Problems	91
Future Damages	96
General	96
Future Flood Damages with National Income Growth Rate	96
Future Flood Damages with Regional Development Growth Rate	101
WRPA 5	103
Description	103
General	103
Topography	103
Climate	106
Economy	106
Flooding in the Area	107
Types and Characteristics of Flooding	107
Mississippi-Red River Backwater Flooding	107
Headwater Flooding	107
Major Historical Floods	107
1927 Flood	107

TABLE OF CONTENTS (Cont)

	Page No.
1932 Flood	107
1937 Flood	108
1945 Flood	108
1958 Flood	108
1968 Flood	108
1973 Flood	109
Present Flood Prevention Program and Remaining Damages	111
Existing Program	111
Structural Program	111
Land Treatment	113
Nonstructural Program	114
Flood Insurance	114
Flood Forecasting	114
Emergency Operations	114
Remaining Flood Problems	114
Future Damages	119
General	119
Future Flood Damages with National Income Growth Rate	119
Future Flood Damages with Regional Development Growth Rate	123
WRPA 6	125
Description	125
General	125
Topography	125
Climate	126
Economy	126
Flooding in the Area	129
Types and Characteristics of Flooding	129
Headwater Flooding	129
Local Flooding	129
Major Historical Floods	129

TABLE OF CONTENTS (Cont)

	Page No.
1927 Flood	129
1932 Flood	129
1947 Flood	131
1953 Flood	131
1958 Flood	131
1973 Flood	131
Present Control Program and Remaining Damages	132
Existing Flood Damage Prevention Program	132
Structural Program	132
Land Treatment	133
Flood Forecasting	133
Remaining Flood Problems	134
Future Damages	136
General	136
Future Flood Damages with National Income Growth Rate	136
Future Flood Damages with Regional Development Growth Rate	139
WRPA 7	141
Description	141
General	141
Topography	141
Climate	142
Economy	144
Flooding in the Area	145
Types and Characteristics of Flooding	145
Backwater Flooding	145
Headwater Flooding	145
Major Historical Floods	145
1951 Flood	145
1958 Flood	146
1961 Flood	146

TABLE OF CONTENTS (Cont)

	Page No.
1964 Flood	146
1973 Flood	146
Present Control Program and Remaining Damages	148
Existing Flood Damage Prevention Program	148
Structural Program	148
Land Treatment	149
Flood Plain Information	150
Flood Forecasting	150
Emergency Operations	150
Remaining Flood Problems	150
Future Damages	153
General	153
Future Flood Damages with National Income Growth Rate	153
Future Flood Damages with Regional Development Growth Rate	157
WRPA 8	159
Description	159
General	159
Topography	159
Climate	162
Economy	162
Flooding in the Area	164
Types and Characteristics of Flooding	164
Mississippi River Flooding	164
Headwater Flooding	164
Tidal Flooding	165
Major Historical Floods	165
1953 Flood	165
1962 Flood	165
1964 Flood	165
1973 Flood	166

TABLE OF CONTENTS (Cont)

	Page No.
Present Control Program and Remaining Damages	167
Existing Flood Damage Prevention Program	167
Structural Program	167
Land Treatment	168
Nonstructural Program	168
Flood Forecasting	169
Emergency Operations	169
Remaining Flood Problems	170
Future Damages	173
General	173
Future Flood Damages with National Income Growth Rate	173
Future Flood Damages with Regional Development Growth Rate	177
WRPA 9	179
Description	179
General	179
Topography	179
Climate	182
Economy	182
Flooding in the Area	184
Types and Characteristics of Flooding	184
Mississippi River and/or Red River Flooding	184
Headwater Flooding	184
Tidal Flooding	184
Major Historical Floods	184
1940 Flood	184
1953 Flood	185
1957 Flood	186
1961 Flood	186
1973 Flood	186
Present Control Program and Remaining Damages	188

TABLE OF CONTENTS (Cont)

Page No.

Existing Flood Damage Prevention Program.................. 188
Structural Program.................................... 188
Land Treatment.. 190
Nonstructural Program................................. 191
Flood Forecasting..................................... 191
Emergency Operations.................................. 191
Remaining Flood Problems.............................. 191
Future Damages... 195
General.. 195
Future Flood Damages with National Income Growth Rate...... 195
Future Flood Damages with Regional Development Growth Rate.. 199
WRPA 10.. 201
Description.. 201
General.. 201
Topography... 201
Climate.. 204
Economy.. 204
Flooding in the Area..................................... 206
Types and Characteristics of Flooding.................. 206
Tidal Flooding.. 206
Headwater Flooding.................................... 207
Mississippi River Flooding............................ 208
Major Historical Floods................................ 208
1947 Flood.. 208
1956 Flood.. 208
1961 Flood.. 208
1964 Flood.. 209
1965 Flood.. 209
1969 Flood.. 210
1973 Flood.. 211

TABLE OF CONTENTS (Cont)

	Page No.
Present Control Program and Remaining Damages	212
Existing Flood Damage Prevention Program	212
Structural Program	212
Land Treatment	214
Nonstructural Program	217
Flood Forecasting	217
Emergency Operations	217
Remaining Flood Problems	217
Future Damages	219
General	219
Future Flood Damages with National Income Growth Rate	219
Future Flood Damages with Regional Development Growth Rate	222
METHODOLOGY	225

LIST OF FIGURES

Figure No.		Page No.
1	Regional Map	5
2-a	Projected Average Annual Damage, Lower Mississippi Region, WRPA's 1-5	19
2-b	Projected Average Annual Damage, Lower Mississippi Region, WRPA's 6-10	20
3	Distribution of Annual Flood Damage, Lower Mississippi Region	21
4	WRPA 1	28
5	WRPA 2 Basin Map with Urban Damage Centers	35
6	Projected Average Annual Damage, WRPA 2	51
7	Distribution of Annual Flood Damage, WRPA 2 . . .	52
8	WRPA 3 Basin Map with Urban Damage Centers	59
9	Projected Average Annual Damages, WRPA 3	72
10	Distribution of Annual Flood Damage, WRPA 3 . . .	73
11	WRPA 4 Basin Map with Urban Damage Centers	79
12-a	Projected Average Annual Damages, WRPA 4	97
12-b	Projected Average Annual Damages, WRPA 4	98
13	Distribution of Annual Flood Damage, WRPA 4 . . .	99
14	WRPA 5 Basin Map with Urban Damage Centers	105
15	Projected Average Annual Damages, WRPA 5	120
16	Distribution of Annual Flood Damage, WRPA 5 . . .	121
17	WRPA 6 Basin Map with Urban Damage Centers	127
18	Projected Average Annual Damages, WRPA 6	137
19	Distribution of Annual Flood Damage, WRPA 6 . . .	138
20	WRPA 7 Basin Map with Urban Damage Centers	143
21	Projected Average Annual Damages, WRPA 7	154
22	Distribution of Annual Flood Damage, WRPA 7 . . .	155
23	WRPA 8 Basin Map with Urban Damage Centers	161
24	Projected Average Annual Damages, WRPA 8	174
25	Distribution of Annual Flood Damage, WRPA 8 . . .	175

LIST OF FIGURES (Cont)

Figure No.		Page No.
26	Flood Control, WRPA 9	181
27	Projected Average Annual Damages, WRPA 9	196
28	Distribution of Annual Flood Damage, WRPA 9	197
29	Flood Control, WRPA 10	203
30	Projected Average Annual Damages, WRPA 10	220
31	Distribution of Annual Flood Damage, WRPA 10	221

LIST OF TABLES

Table No.		Page No.
1	Flood Control Storage, 1970, Lower Mississippi Region	12
2	Summary of Local Protection Projects, 1970, Lower Mississippi Region	12
3	Land Treatment, 1970, Lower Mississippi Region	13
4	Remaining Flood Problems, Existing Conditions, Lower Mississippi Region	17
5	Projected Average Annual Flood Damages, National Income Growth, Lower Mississippi Region	22
6	Projected Average Annual Flood Damages, Regional Development Growth, Lower Mississippi Region	24
7	Summary of Protection Projects, 1970, WRPA 1	31
8	Remaining Flood Problems, Existing Conditions, WRPA 1	31
9	Existing and Projected Average Annual Flood Damages, National Income Growth, WRPA 1	32
10	Existing and Projected Average Annual Flood Damages, Regional Development Growth, WRPA 1	32
11	Flood Control Storage, 1970, WRPA 2	43
12	Summary of Local Protection Projects, 1970, WRPA 2	43

LIST OF TABLES (Cont)

Table No.		Page No.
13	Land Treatment, 1970, WRPA 2	45
14	Remaining Flood Problems, Existing Conditions (1970), WRPA 2	49
15	Projected Average Annual Flood Damages, National Income Growth, WRPA 2	53
16	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 2	55
17	Flood Control Storage, 1970, WRPA 3	66
18	Summary of Local Protection Projects, 1970, WRPA 3	66
19	Land Treatment, WRPA 3	67
20	Remaining Flood Problems (1970), Existing Conditions, WRPA 3	70
21	Existing and Projected Average Annual Flood Damages, National Income Growth, WRPA 3	74
22	Existing and Projected Average Annual Flood Damages, Regional Development Growth, WRPA 3 . .	76
23	Flood Control Storage, 1970, WRPA 4	90
24	Summary of Local Protection Projects, 1970, WRPA 4	90
25	Land Treatment, 1970, WRPA 4	91
26	Remaining Flood Problems, Existing Conditions, WRPA 4	95
27	Existing and Projected Average Annual Flood Damage, National Income Growth, WRPA 4	100
28	Existing and Projected Average Annual Flood Damage, Regional Development Growth, WRPA 4 . .	102
29	Flood Control Storage, 1970, WRPA 5	112
30	Summary of Local Protection Projects, 1970, WRPA 5	112
31	Land Treatment, 1970, WRPA 5	113
32	Remaining Flood Problems (1970), Existing Conditions, WRPA 5	118
33	Existing and Projected Average Annual Flood Damage, National Income Growth, WRPA 5	122

LIST OF TABLES (Cont)

Table No.		Page No.
34	Existing and Projected Average Annual Flood Damage, Regional Development Growth, WRPA 5 . .	124
35	Summary of Local Protection Projects, 1970, WRPA 6	133
36	Land Treatment, 1970, WRPA 6	133
37	Remaining Flood Problems (1970), Existing Conditions, WRPA 6	135
38	Projected Average Annual Flood Damages, National Income Growth, WRPA 6	139
39	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 6	139
40	Flood Control Storage, 1970, WRPA 7	149
41	Summary of Local Protection Projects, 1970, WRPA 7	149
42	Land Treatment, 1970, WRPA 7	149
43	Remaining Flood Problems, Existing Conditions, WRPA 7	152
44	Projected Average Annual Flood Damages, National Income Growth, WRPA 7	156
45	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 7	157
46	Summary of Local Protection Projects, 1970, WRPA 8	168
47	Land Treatment, 1970, WRPA 8	168
48	Remaining Flood Problems, Existing Conditions, WRPA 8	172
49	Projected Average Annual Flood Damages, National Income Growth, WRPA 8	176
50	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 8	177
51	Flood Control Storage, 1970, WRPA 9	190
52	Summary of Local Protection Projects, 1970, WRPA 9	190
53	Land Treatment, 1970, WRPA 9	191

Table No.		Page No.
54	Remaining Flood Problems, Existing Conditions, WRPA 9	193
55	Projected Average Annual Flood Damages, National Income Growth, WRPA 9	198
56	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 9	199
57	Summary of Local Protection Projects, 1970, WRPA 10	214
58	Land Treatment, 1970, WRPA 10	214
59	Remaining Flood Problems, Existing Conditions, WRPA 10	216
60	Projected Average Annual Flood Damages, National Income Growth, WRPA 10	222
61	Projected Average Annual Flood Damages, Regional Development Growth, WRPA 10	223

PHOTOGRAPHS

The photographs included in this appendix were furnished by:

	Page No.
U. S. Army Corps of Engineers	8, 13, 14, 40, 44, 46, 61, 62, 65, 68, 83, 85, 86, 89, 101, 110, 113, 115, 116, 117, 123, 130, 163, 164, 169, 171, 185, 189, 194, 206, 207, 210, 212, 213, 218
U. S. Department of Agriculture, Soil Conservation Service	47, 147
Vicksburg Evening Post, Vicksburg, Miss.	15, 93

I N T R O D U C T I O N

PURPOSE

The purpose of this Appendix is to present an assessment of the current and future flood problems in the Lower Mississippi Region and to provide input data for the formulation of a regional framework program.

SCOPE

The study is preliminary or reconnaissance in nature and preliminary, generalized hydrology and hydraulic data were utilized extensively, along with quadrangle maps, and previous and current studies, when available. Field work was generally limited to reconnaissance of urban problem areas and certain areas which could not be evaluated otherwise.

Information on prospective flood damages due to future developments was evaluated for both the National Income and Regional Development objectives. Projections were made of flood damages in the years 1980, 2000, and 2020 for each of the objectives and individually for upstream watersheds and principal stream reaches.

RELATIONSHIP TO OTHER APPENDIXES

Background material for this appendix is presented in several appendixes. Appendixes B, C, and F, Economics, Regional Climatology, Hydrology and Geology, Land Resources, respectively, include basic data utilized in assessing the region's flood problems. Details on existing flood control works are contained in Appendix D, Inventory of Facilities. The framework program developed to alleviate flood problems of the region is included in Appendix T, Plan Formulation.

A thorough review of this appendix and Appendixes D and T is necessary to gain a comprehensive understanding of existing flood problems in the region and the possible solutions to those problems.

PRESENTATION OF MATERIALS

The arrangement of this appendix consists of an introductory section followed by a regional summary section and then summaries for each of the water resource planning areas (WRPA's). The regional summary consolidates and presents information on the flood problems contained in the individual WRPA sections. The material in the regional summary and each of the WRPA sections includes a description of the area studied, types and characteristics of flooding in the area, a history of major floods, a description of the existing flood control program, an evaluation of remaining flood problems and future needs.

REGIONAL SUMMARY

REGIONAL SUMMARY

DESCRIPTION OF THE REGION

General

The drainage basin of the Mississippi River is the fourth largest in the world, following in size the watersheds of the Amazon, Congo, and Nile Rivers. The Mississippi River Basin covers all or part of 31 of the 48 contiguous United States and two Canadian Provinces, and comprises 41 percent of the area of the 48 contiguous states. Waters from as far east as New York State and as far west as Montana contribute to the flow in the Lower Mississippi River.

Flooding in the Lower Mississippi Region has always presented a threat to the inhabitants of the region and during the past 150 years, flooding has been of grave concern to the Nation because of the devastating losses, both human and economic, which have accompanied great main stem floods. The flood damages produced by the Lower Mississippi River drastically emphasized the need for flood control in the valley to the early settlers and as early as 1727, a levee in the vicinity of New Orleans was completed. As the population of the valley increased and prospered, more land was cleared and more levees were constructed to protect the land from the ravages of flooding. By 1844, the levee system was practically continuous on the west bank from below New Orleans northward to the mouth of the Arkansas River. Similarly, levees on the east bank extended from well below New Orleans to Baton Rouge and at several locations between Vicksburg and Memphis. All of this work was accomplished by local interests using their own resources.

The frequent flooding and resultant losses in the region, culminating with the great flood of 1927, prompted legislation authorizing Federal participation in massive efforts to control main stem flooding. Similar legislation was passed authorizing structural control of flooding on major tributaries to the Mississippi River. Much work has been completed in these flood-prone areas and work continues, but despite all efforts expended to date, flooding remains a major problem throughout much of the Lower Mississippi Region.

Topography

The Lower Mississippi Region comprises 102,404 square miles of area contained within the states of Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana, and is bisected by the Mississippi River below Cairo, Illinois, as shown on figure 1.

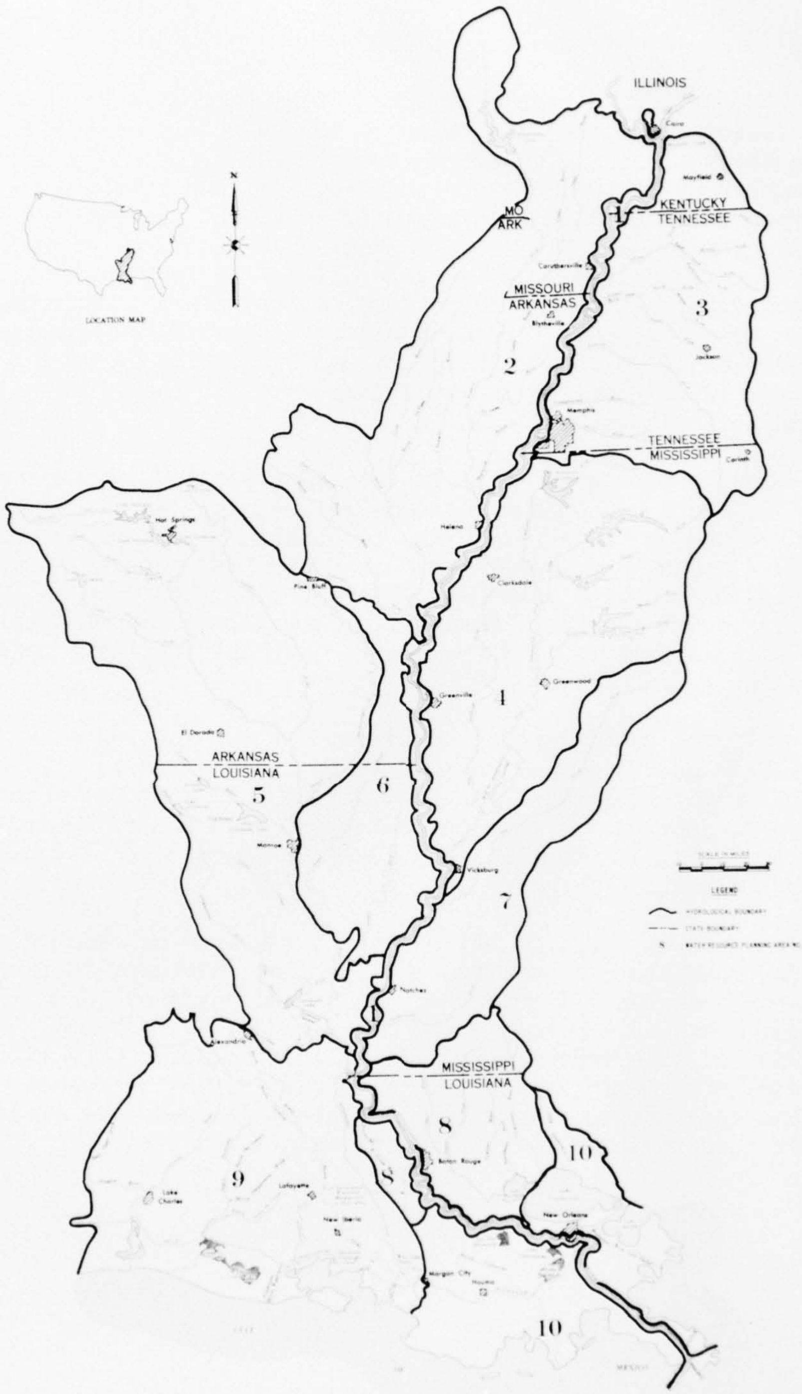
The Region is composed of widely varying landforms which range from the Mississippi River alluvial area, which is practically devoid of relief, to parts of the Ozark Mountains in Arkansas and Missouri. About 35,000 square miles or 34 percent of the region consists of the alluvial plain or "delta" of the Mississippi River, while the remaining 66 percent varies from gently rolling hills to loessal bluffs to abrupt steep hill lands as in the Missouri Ozark Mountains. Due to the widely varying topography, drainage in the region ranges from excellent in some of the steeper hill areas to practically nonexistent in the Mississippi River lowlands. The region is drained by several major tributaries, including the St. Francis, portions of the White and Arkansas, and the Obion-Forked Deer Rivers in the northern one-half, and the Red, Atchafalaya, Calcasieu, Mermentau, Yazoo, Ouachita, and Big Black Rivers in the Southern half.

For planning purposes, the Region was divided into 10 water resource planning areas (WRPA's), whose boundaries generally follow major hydrologic boundaries. WRPA 1 is the exception, consisting of the area along the main stem of the Mississippi River lying between the landside toes of the main stem levees where levees exist, and where no levees exist, WRPA 1 has its boundaries as the top bank of the Mississippi River. Specific descriptions of all WRPA's are contained in the individual WRPA sections.

Climate

The entire Lower Mississippi Region experiences a relatively mild climate with the winters being described as mild in the southern areas to fairly cold in the northern areas. The summers throughout the region are described as quite hot with temperatures frequently approaching or exceeding the 100° F. mark. Weather throughout the region is affected to some extent by the Gulf of Mexico and the tropical storms which are spawned there. The southern areas experience the brunt of many hurricanes and other tropical storms with their resulting flooding and wind damage, while the northern areas of the region are generally free from the actual hurricanes but often receive high winds and heavy rainfall as a result of these storms.

The Region has an annual frost-free growing season varying from 7 months in the north to 8 months in the south. The mean annual temperature varies from around 60° F. in the north to about 68° F. in the south. Rainfall in the north is about 50 inches annually compared to about 60 inches annually in the southern areas.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

REGIONAL MAP

FIGURE 1

Economy

In 1970, 6,293,233 people resided in the Lower Mississippi Region. This population is projected to rise by the year 2020 to 10,196,000 under the National Income objective and to 11,655,000 under the Regional Development objective. Most of the region's population was centered around urban areas in 1970 with New Orleans, Louisiana (SMSA population 1,060,290), and Memphis, Tennessee (SMSA population 760,100), being the two largest metropolitan areas in the region. In 1970, agricultural workers accounted for almost 10 percent of the working population of the region; however, most future population increases are projected to occur in the urban centers with this trend continuing until in 2020 only about 2-1/2 percent of the work force will be comprised of persons engaged in agricultural pursuits.

The major economic pursuits in the Lower Mississippi Region include agriculture, forest and fishery production, mining, and manufacturing of food and kindred products, textiles, chemicals, paper, petroleum products and primary metals along with many supporting service industries. Waterborne commerce also plays an extremely important role in the burgeoning economy of the Lower Mississippi Region, as the Mississippi River is an important route to regional, national, and international trade for the inland ports along its course.

In 1968, the gross manufacturing product for the region was \$4.2 billion1/ and is projected to rise to \$38.01/ and \$44.81/ billion in 2020 under the National Income and Regional Development objectives, respectively. During the same period, gross farm marketing receipts are projected to rise from \$2.1 billion1/ to \$3.81/ and \$4.2 billion1/ under the different objectives.

Land use in the region, which has a total area of about 65.5 million acres, consists of cropland, 31.1 percent; pasture, 10.3 percent; forests and woodlands, 45.2 percent; urban and built-up lands, 3.6 percent; water areas, 4.7 percent; and other lands, 5.1 percent. Current projections indicate that urban lands will increase to more than 6 percent of the total land area by 2020 with significant increases occurring in cropland and pasture. As a result, forest lands and other lands will experience a decrease if their projections are realized.

1/ 1967 Dollars

FLOODING IN THE REGION

Types and Characteristics of Flooding

Flood problems in the Lower Mississippi Region may generally be categorized into three major types - headwater flooding, backwater flooding and tidal flooding. The first and second types occur throughout the region, while tidal flooding is peculiar to coastal areas, thus is limited to WRPA's 8, 9, and 10, and is a direct result of tidal surges associated with tropical storms and hurricanes.

Headwater flooding, which is common throughout the region, is produced on lands adjacent to tributary streams by excessive stages on these streams and is normally the result of rainstorms occurring over the drainage basins of the tributary streams. Headwater flooding on the Mississippi River is a common occurrence and is generally produced by excessive general rainfall in the central United States. This condition, augmented by snowmelt in the upper tributary areas, has traditionally produced the great floods of the Mississippi River Basin.

Backwater flooding is a phenomenon produced by excessive stages on the Mississippi River main stem. These excessive stages create flooding along tributary streams due to a damming effect which holds or slows runoff in the tributary, raising its stage, and by actually reversing the flow of the tributary stream some distance upstream from its mouth, allowing main stem flows to enter the tributary basin. These stage-raising effects then produce general, long-duration flooding of the adjacent floodplain lands.

Flooding has occurred practically every year in various parts of the region with the great main stem floods of 1927 and 1937 remaining outstanding as the worst recorded and documented floods of the past century. Hurricanes Betsy and Camille in 1965 and 1969, respectively, produced both tidal flooding and headwater flooding along coastal areas and are recorded as the two major storms of recent years.

Major Historical Floods

Flooding in the Lower Mississippi Region throughout its history has been practically an annual occurrence. Prior to construction of the existing levee system along the main stem of the river, these floods inundated hundreds of square miles on either side of the river, and created an extremely hostile environment for those who tried to settle in the alluvial plain.

The first recorded flood on the Mississippi River began in early March, 1543, crested about 40 days later, and the river remained out of its banks for a total of about 80 days. This flood occurred during the expedition begun by DeSoto, during which he discovered the Mississippi River.

Many other great floods have been recorded in the Lower Mississippi Valley, and among them were devastating overflows occurring in 1849, 1912, 1913, and 1916. During the past 50 years, four major main stem floods have occurred along the "Lower River." These floods were in 1927, 1937, 1945, 1950, and 1973, with the '27 and '37 floods generally being considered the most devastating ever. More recent floods resulting from Hurricanes Betsy, 1965, and Camille, 1969, also caused extensive damage and loss of life.

1927 Flood

During the spring of 1927 there occurred the most devastating flood in the history of the Lower Mississippi Valley. As the river rose out

Mississippi River flooding in Arkansas City, Arkansas, May 1927.

of its banks, it ravaged the earthen levees which had been constructed to control it, subsequently destroyed more than 5 miles of main line levees, inundating more than 26,000 square miles, and flooded cities, towns, and farms. Transportation was halted, industry was paralyzed, and property was destroyed equivalent to more than a billion dollars today. The damage that cannot be measured in dollars was felt in the loss of 214 lives and by more than 637,000 people who were forced to flee their homes.

This disaster awakened the conscience of the Nation to the need for flood control on the Mississippi River and resulted in the Flood Control Act of 1928 which marks the beginning of the present flood control project on the river.

1937 Flood

Beginning in late 1936 and continuing through most of January 1937, the Ohio and Mississippi Valleys experienced a series of abnormally heavy rains with climatic intensities occurring during 20-25 January 1937. These rains created record-high stages on the Lower Mississippi River from Cairo, Illinois, to Helena, Arkansas. This flood gave the first real test to the flood control works which had been constructed following the tragic 1927 flood, and in the Lower Mississippi Valley they held, even though peak discharges were higher than those experienced during the 1927 flood.

In spite of the functioning of the flood control structures, extensive damage was produced by backwater flooding on the major Mississippi River tributaries and by operation of the Birds Point-New Madrid floodway in Missouri in order to save the city of Cairo, Illinois, from complete inundation. This flood served as a basis for revising the "project flood" to improve flood protection in the Lower Mississippi Valley.

1965 Hurricane Betsy

Hurricane Betsy, which struck the Louisiana coast on 9 September 1965, just west of Grand Isle, Louisiana, was the most destructive hurricane that had ever entered the region. She inundated 4,800 square miles with tides up to 16 feet above mean sea level. As a result of this catastrophe, 81 people lost their lives and 250,000 persons had to be evacuated. The damages from Betsy amounted to $372 million, of which $168 million was from tidal overflow. These damages do not reflect the disruption of transportation, communication, and utility services which lasted for several weeks after the storm occurrence.

1969 Hurricane Camille

Hurricane Camille, one of the most intensive storms of record, sideswiped the lower portion of the region on 17 August 1969. In the wake of this devastating storm 9 persons were left dead and 10 missing,

and thousands were evacuated. Damages in the region were estimated at $250 million.

1973 Flood

In the Fall and Winter of 1972, excessive rainfall over the Lower Mississippi Region began to produce a hydrologic situation alarmingly similar to that which occurred immediately preceding the Great Flood of 1927. Flood control storage was being utilized at an unprecendented rate, and as time progressed many reservoirs became filled and began overflowing their emergency spillways. Additionally, the soil became saturated with the continual rainfall, adding to the already critical flood potential.

Recognizing that there was a high probability that the Lower Mississippi Region would experience a major flood, Federal, State, and Local flood control organizations began to prepare for the necessary flood fighting effort. Mock Flood-Fights were conducted, inspections were made of the flood control structures in the region and flood-fighting materials were stockpiled as the "Delta People" prepared to combat "Old Man River" once again.

Then, early in March 1973, the Mississippi River began a rise which kept it out of its banks for more than two months through a two-crested flood which overall was the third worst flood in the records of the region for its stage heights, but the greatest flood of record for duration.

Tributary flooding throughout the Region was one of the most critical problems with record or near-record floods occurring on several of the major tributaries of the region. Streams such as the Yazoo, St. Francis, White and Atchafalaya proved to be extremely critical areas and each forced many families to flee their homes to escape the rising waters.

Total losses from this flood will never be fully accounted for, but estimates show that known damages exceed more than 700 million dollars with at least 28 deaths directly attributable to the flood and other deaths being flood-related, over the more than 13 million acres inundated by the floodwaters.

In addition to the floods described in the preceding paragraphs, many smaller floods have occurred practically every year on tributary streams and rivers in the region. These smaller floods have caused and continue to cause much damage throughout the region even when the Mississippi River is far from flood stage.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

Structural improvements which reduce damages from flooding have been constructed throughout the region by the joint efforts of Federal, State, and local agencies. Tables 1 and 2 summarize these improvements which include levees and floodwalls (3780.2 miles), channel improvements (11,554.5 miles), 37 pumping plants, and flood control reservoirs with a total storage capacity of about 6,028,000 acre-feet. In addition to the Federally sponsored projects listed, there are small flood control projects throughout the basin which have been constructed by private individuals or organizations for the purpose of providing flood protection to specific small areas. These small projects, too numerous to list, play an important role in the overall flood control program of the region.

Nonstructural Program

Flood Plain Information studies and reports as well as technical assistance are provided to urban areas for use in management of their floodplain areas. The local government may exercise one or more nonstructural approaches to floodplain management, such as zoning ordinances, subdivision regulations, construction codes, and flood-proofing of existing structures.

Flood insurance studies provide another source of floodplain information where these studies are available. These studies are conducted to provide a basis for rate determination and issuance of flood insurance. The flood insurance program is currently becoming quite active in the Lower Mississippi Region.

To date 43 floodplain information reports have been completed or are underway in the Lower Mississippi Region. Additionally, 28 flood insurance studies have been completed or are underway.

Land Treatment

Presently 19,127,000 acres of land located in the Lower Mississippi Region are adequately treated to reduce erosion and sedimentation and aid in the reduction of surface runoff. Data on acres with adequate treatment by WRPA are shown in table 3. Additional data on land use and land treatment are included in the Land Resources Appendix.

Flood Forecasting

The National Weather Service, with the Lower Mississippi River Forecast Center at Slidell, Louisiana, and River District Offices at New Orleans, and Lake Charles, Louisiana; Jackson, Mississippi; Little Rock, Arkansas; Memphis, Tennessee; and Cairo, Illinois, provides a

Table 1 - Flood Control Storage, 1970, Lower Mississippi Region 1/

WRPA	Flood Control - Storage in 1,000 Acre-Feet: Major Reservoir	Small Reservoir	Totals
1	-	-	-
2	582.0	48.9	630.9
3	-	188.6	188.6
4	3809.8	262.2	4072.0
5	972.4	40.9	1013.3
6	-	-	-
7	-	62.2	62.2
8	-	-	-
9	-	61.3	61.3
10	-	-	-
Total	5364.2	664.1	6028.3

1/ Additional storage exists in tributary regions, lowering stages on main-stem Mississippi River floods and aiding forecasting.

Table 2 - Summary of Local Protection Projects, 1970, Lower Mississippi Region 1/

WRPA	Levees and Floodwalls (Miles)	Channel Improvement2/ (Miles)	Bank Stabilization (Miles)	Pumping Plants (No.)	(Total c.f.s.)
1	1525.0	954.0	971.0	-	-
2	668.8	987.5	41.1	5	14,000
3	22.3	1054.0	-	13	8,237
4	260.8	3451.8	-	3	1,465
5	262.5	436.2	-	5	565
6	-	2035.7	-	-	-
7	0.8	526.4	-	1	100
8	-	184.1	-	-	-
9	526.0	1811.0	-	9	3,102
10	514.0	72.0	-	1	154
Total	3780.2	11554.5	1012.1	37	27,623

1/ Consists of projects in both upstream watersheds and principal reaches.
2/ Channel improvement for navigation not included.

Table 3 - Land Treatment, 1970, Lower Mississippi Region

WRPA	Lands Adequately Treated Acres (1,000's)
1	0
2	3,594
3	2,617
4	1,968
5	3,057
6	940
7	1,325
8	1,268
9	2,535
10	1,823
Region Total	19,127

Flooding along Ouachita River at Arkadelphia, Arkansas, 1968.

river and flood forecast service for the LMRCS area. Hurricane, storm surge, and storm tide forecasts for the coastal section are provided by the New Orleans Weather Service Forecast Center. Main stem Mississippi River flood forecasting, Cairo, Illinois, to New Orleans, Louisiana, is performed by the NOAA's River Forecast Center at Slidell.

Sardis Lake, Little Tallahatchie River, Mississippi.

Remaining Flood Problems

Flooding remains a major problem throughout the Lower Mississippi Region, ranging from relatively long duration flooding of the Mississippi River, to major tributary flooding, to tidal flooding, to relatively short, intense floods occurring along small streams. Generally these problems lie in areas where authorized works have not been constructed or where little or no protection is currently provided.

Flooding problems in the noncoastal WRPA's are generally similar with upstream areas being subject to headwater flooding of short to medium duration, while the downstream alluvial areas may experience both headwater flooding and backwater flooding from the Mississippi River. The WRPA's bordering the Gulf of Mexico are subject additionally to tidal flooding produced by hurricanes and tropical storms.

Total average annual flood damage in the region is more than $212 million under 1970 conditions. Table 4 summarizes the area subject to flooding and average annual damages due to flooding in each WRPA. The various WRPA summaries provide more detailed data for specific subbasins.

Suburban flooding, Vicksburg, Mississippi, March 1973.

In the presentation of damage figures, authorized projects having short construction periods that were initiated by the end of FY 1973 were considered to be in place. Those projects requiring a long, continuing construction period were considered only as their completed portions would affect flood damages at the end of FY 1973.

It should be further understood that an estimate of monetary damage alone can not completely show the losses from flooding. Also to be recognized are the hardships and inconveniences suffered by families forced to flee from flooded areas, the problems imposed by the closing of frequently traveled roads, the massive effort required in attempts to save unprotected or partially protected areas, and the generally disrupting effect of flooding on the economy of a region. Also to be considered is the danger to people living in floodprone areas and to flood workers.

Table 4 - Remaining Flood Problems, 1970 Conditions, Lower Mississippi Region

WRPA	Area Subject to Floods (1,000 Acres)		Average Annual Damages Due To Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total
1														
Headwater	1,190	-	2,800	20	416	3,236	-	-	-	-	2,800	20	416	3,236
Backwater	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2														
Headwater	4,858	2,616	20,129	1,402	3,873	25,404	29,232	140	4,330	33,702	49,361	1,542	8,203	59,106
Backwater	861	-	455	-	80	535	-	-	-	-	455	-	80	535
3														
Headwater	1,173	828	4,610	6,973	552	12,135	5,444	1,262	1,776	8,482	10,054	8,235	2,328	20,617
Backwater	274	-	306	95	40	441	-	-	-	-	306	95	40	441
4														
Headwater	2,048	1,877	9,220	1,105	4,617	14,942	17,506	1	1,910	19,417	26,726	1,106	6,527	34,359
Backwater	724	-	1,579	260	216	2,055	-	-	-	-	1,579	260	216	2,055
5														
Headwater	1,481	2,667	2,622	994	1,854	5,470	11,534	115	1,495	13,144	14,156	1,109	3,349	18,614
Backwater	557	-	1,270	48	341	1,659	-	-	-	-	1,270	48	341	1,659
6														
Headwater	1,033	2,425	2,794	68	674	3,536	13,854	21	582	14,457	16,648	89	1,256	17,993
Backwater	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7														
Headwater	290	487	442	1,091	150	1,683	2,427	13	710	3,150	2,869	1,104	860	4,833
Backwater	81	-	239	118	266	623	-	-	-	-	239	118	266	623
8														
Headwater	1,017	1,029	142	847	7	996	2,967	808	541	4,316	3,109	1,655	548	5,312
Tidal	296	-	-	3	-	3	-	-	-	-	-	3	-	3
Back-water	61	-	13	-	6	19	-	-	-	-	13	-	6	19
9														
Headwater	2,720	4,879	589	619	224	1,432	8,973	41	111	9,125	9,562	660	335	10,557
Tidal	1,915	-	223	1,929	1,140	3,292	-	-	-	-	223	1,929	1,140	3,292
Back-water	822	-	64	-	-	64	-	-	-	-	64	-	-	64
10														
Headwater	252	2,621	15	39	3	57	4,518	637	141	5,296	4,533	676	144	5,353
Tidal	2,254	-	362	21,239	2,637	24,238	-	-	-	-	362	21,239	2,637	24,238
REGION TOTALS														
Headwater	16,062	19,429	43,363	13,158	12,370	68,891	96,455	3,038	11,596	111,089	139,818	16,196	23,966	179,980
Backwater	3,380	-	3,926	521	949	5,396	-	-	-	-	3,926	521	949	5,396
Tidal	4,465	-	585	23,171	3,777	27,533	-	-	-	-	585	23,171	3,777	27,533
Grand Total (Not Additive)		19,429	47,874	36,850	17,096	101,820	96,455	3,038	11,596	111,089	144,329	39,888	28,692	212,909

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development, which are based on alternative levels of economic growth. The National Income objective is based on the economic activity indicated by OBERS projections, while the Regional Development objective is based on a higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources. Figures 2 and 3 illustrate the trends and relative magnitudes of future damages. Details related to the alternative levels of economic development are contained in the Economics Appendix.

Future Flood Damages - National Income Growth Rate

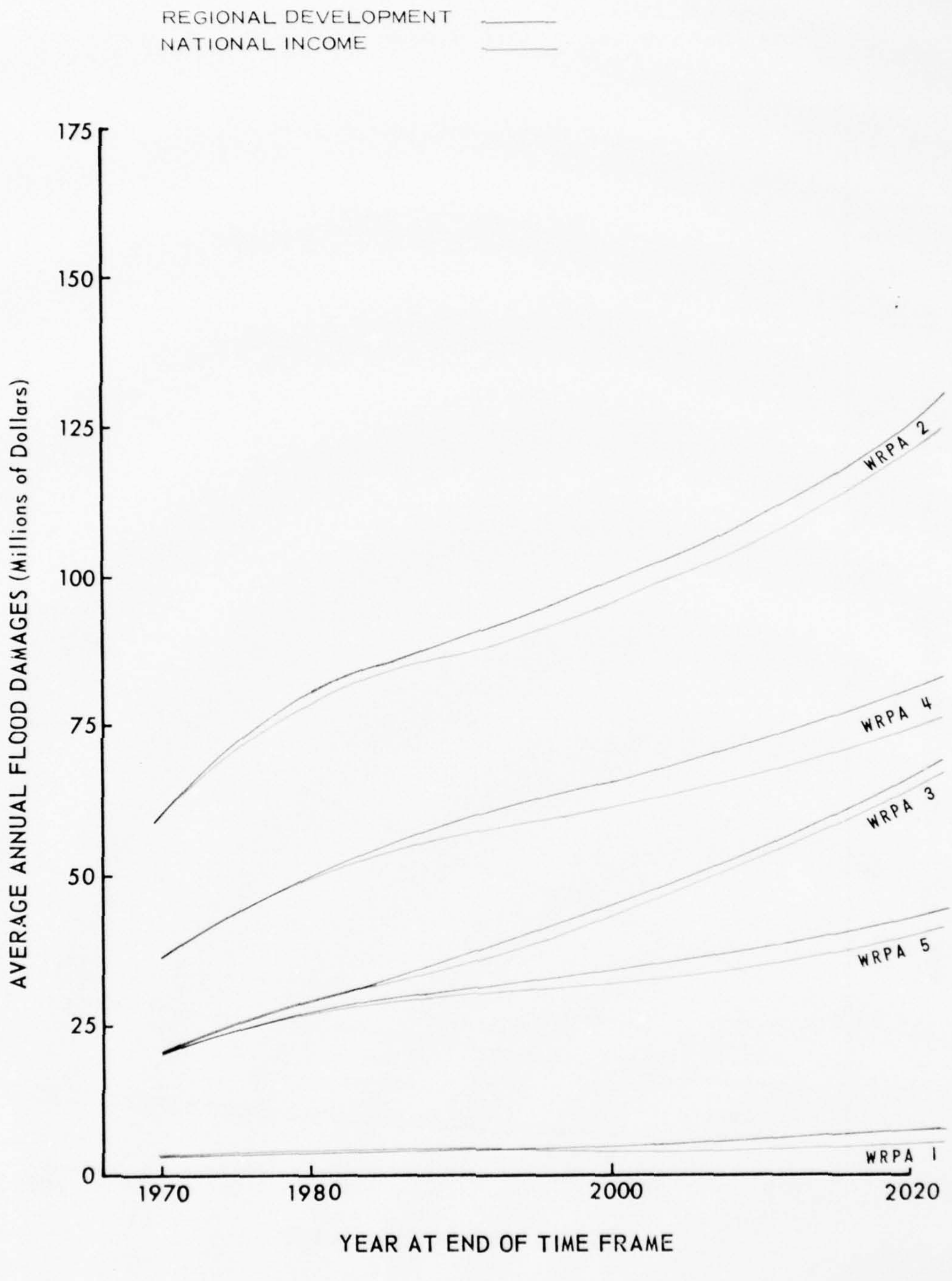
The levels of average annual damages for the base year (1970) and the target years 1980, 2000, and 2020, are listed in table 5 by WRPA and source of flooding. The estimates of future damage levels are based on economic and land use projections for the National Income objective as described in the Economics and Land Resources Appendixes. Projects requiring a construction period of only a few years and which were under construction by FY 1973, are assumed to be in place. Projects requiring a long, continuing construction period (some as long as 20 years or more) to provide a significant degree of protection were considered only as the completed portion of the project would affect flooding and damages at the end of FY 1973.

Under the National Income objective, the projected average annual damage levels for 1980, 2000, and 2020 are $281,962,000, $365,230,000, and $490,189,000, respectively.

Future Flood Damages - Regional Development Growth Rate

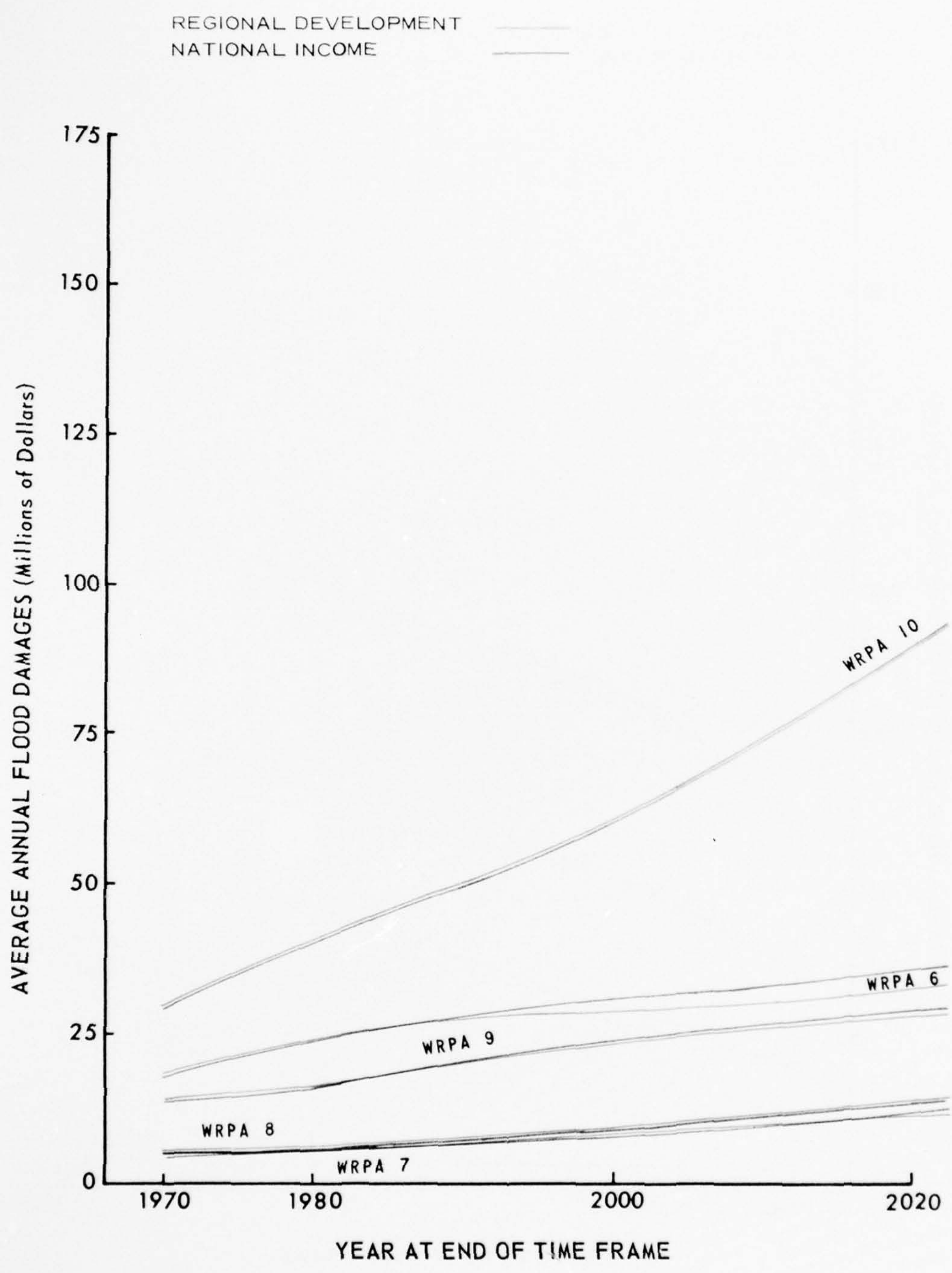
Estimated future flood damages as determined under the Regional Development objective are listed in table 6. Future rural flood damages under this objective are approximately the same as those estimated for the National Income growth rate, while urban damages show an increase under this objective.

The Regional Development objective damage levels as projected show average annual losses due to flooding of $285,427,000, $382,184,000, and $512,944,000 for 1980, 2000, and 2020, respectively.



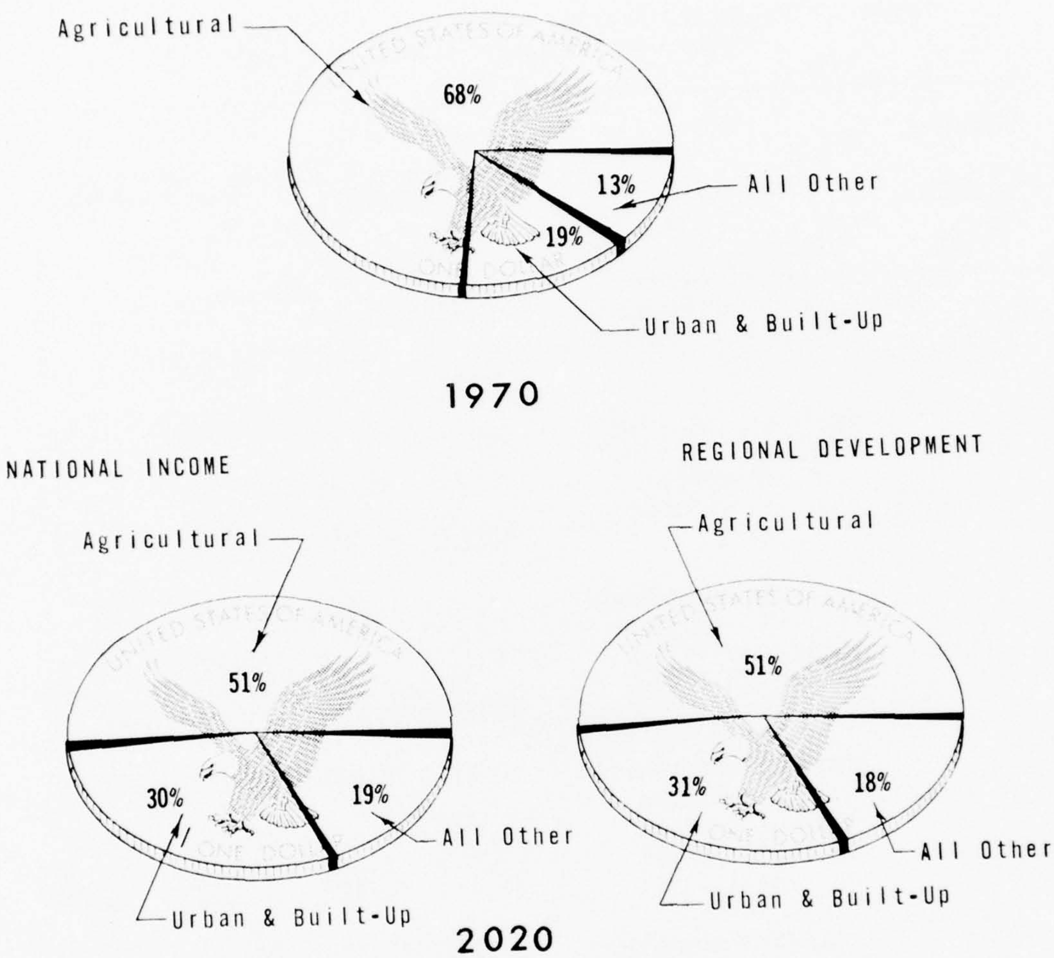
PROJECTED AVERAGE ANNUAL DAMAGE
LOWER MISSISSIPPI REGION
WRPA'S 1-5

Figure 2-a



PROJECTED AVERAGE ANNUAL DAMAGE
LOWER MISSISSIPPI REGION
WRPA'S 6-10

Figure 2-b



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

LOWER MISSISSIPPI REGION

Figure 3

Table 5 - Projected Average Annual Flood Damages-National Income Growth, Lower Mississippi Region

Planning Area	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
1	Upstream Watersheds	0	0	0	0
	Principal Streams				
	Headwater Flood	3,236	3,929	4,470	5,119
	Backwater Flood	0	0	0	0
	Total	3,236	3,929	4,470	5,119
2	Upstream Watersheds	33,702	42,037	53,673	69,242
	Principal Streams				
	Headwater Flood	25,404	36,643	41,058	54,082
	Backwater Flood	535	698	853	960
	Total	59,641	79,378	95,584	124,284
3	Upstream Watersheds	8,482	10,509	14,962	21,324
	Principal Streams				
	Headwater Flood	12,135	17,940	27,359	43,901
	Backwater Flood	441	632	1,013	1,678
	Total	21,058	29,081	43,334	66,903
4	Upstream Watersheds	19,417	29,014	35,512	43,499
	Principal Streams				
	Headwater Flood	14,942	17,827	21,936	28,382
	Backwater Flood	2,055	2,542	3,246	3,594
	Total	36,414	49,383	60,694	75,475
5	Upstream Watersheds	13,144	17,349	22,286	28,951
	Principal Streams				
	Headwater Flood	5,470	6,152	7,248	9,066
	Backwater Flood	1,659	1,988	2,636	3,322
	Total	20,273	25,489	32,170	41,339
6	Upstream Watersheds	14,457	19,980	24,025	29,105
	Principal Streams				
	Headwater Flood	3,536	4,357	4,611	4,766
	Backwater Flood	0	0	0	0
	Total	17,993	24,337	28,636	33,871
7	Upstream Watersheds	3,150	4,591	5,922	7,982
	Principal Streams				
	Headwater Flood	1,683	1,845	2,476	3,595
	Backwater Flood	623	657	751	849
	Total	5,456	7,093	9,149	12,426

Table 5 - Projected Average Annual Flood Damages-National Income Growth, Lower Mississippi Region (con.)

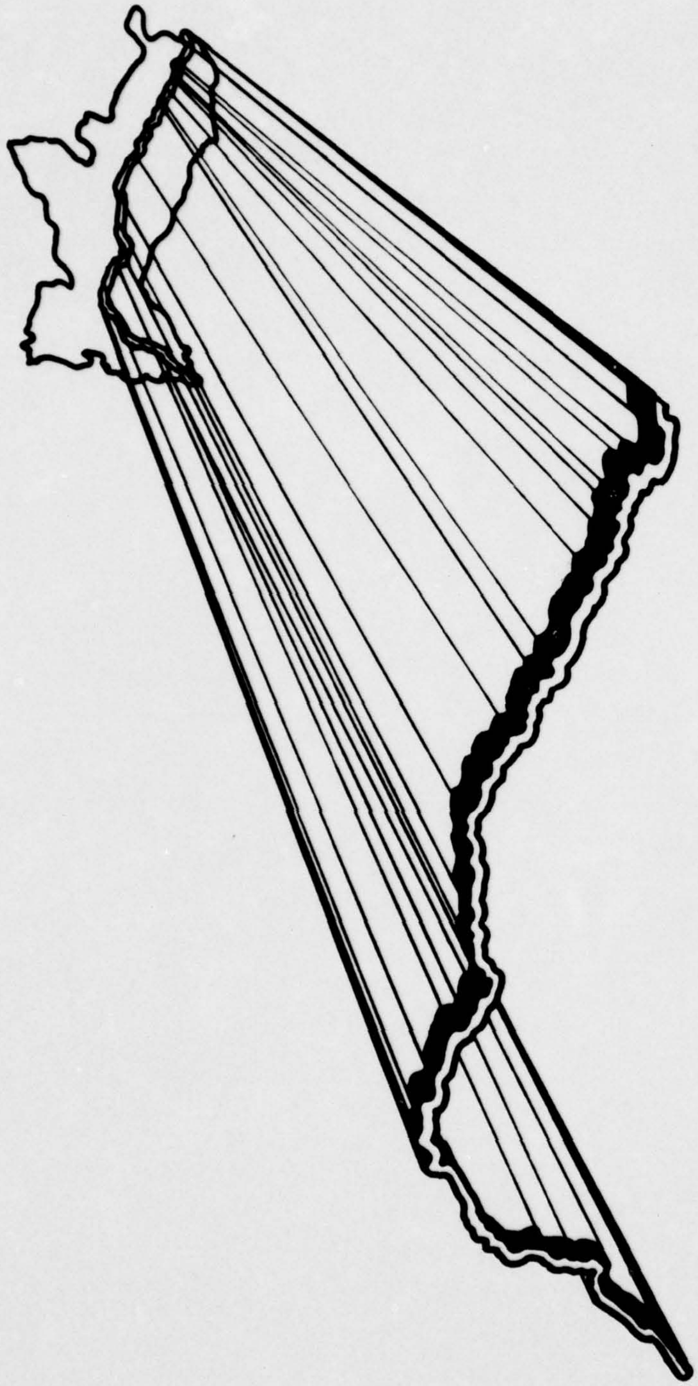
Planning Area	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
8	Upstream Watersheds	4,316	5,170	7,385	10,901
	Principal Streams				
	Headwater Flood	996	1,318	2,078	3,410
	Tidal Flood	3	5	7	11
	Miss. River (BW) Flood	19	24	29	36
	Total	5,334	6,517	9,499	14,358
9	Upstream Watersheds	9,125	10,426	13,086	15,473
	Principal Streams				
	Headwater Flood	1,432	1,824	2,168	2,547
	Tidal Flood	3,292	3,683	4,443	5,368
	Miss. River (BW) Flood	64	82	102	147
	Total	13,913	16,015	19,799	23,535
10	Upstream Watersheds	5,296	6,350	8,294	10,545
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	24,238	34,315	53,483	82,166
	Total	29,591	40,740	61,895	92,879
REGION TOTAL					
	Upstream Watersheds	111,089	145,426	185,145	237,022
	Principal Streams				
	Headwater Flood	68,891	91,910	113,522	155,036
	Backwater Flood	5,396	6,623	8,630	10,586
	Tidal Flood	27,533	38,003	57,933	87,545
	Total	212,909	281,962	365,230	490,189

Table 6 - Projected Average Annual Flood Damages-Regional Development Growth, Lower Mississippi Region

Planning Area	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
1	Upstream Watersheds	0	0	0	0
	Principal Streams				
	Headwater Flood	3,236	4,423	4,962	5,754
	Backwater Flood	0	0	0	0
	Total	3,236	4,423	4,962	5,754
2	Upstream Watersheds	33,702	42,179	57,114	73,077
	Principal Streams				
	Headwater Flood	25,404	38,151	42,030	56,508
	Backwater Flood	535	692	854	959
	Total	59,641	81,022	99,998	130,544
3	Upstream Watersheds	8,482	10,522	15,418	21,987
	Principal Streams				
	Headwater Flood	12,135	17,957	27,948	45,070
	Backwater Flood	441	636	1,025	1,699
	Total	21,058	29,115	44,391	68,756
4	Upstream Watersheds	19,417	29,026	37,521	46,076
	Principal Streams				
	Headwater Flood	14,942	18,437	24,113	32,132
	Backwater Flood	2,055	2,556	3,649	4,046
	Total	36,414	50,019	65,283	82,254
5	Upstream Watersheds	13,144	17,405	24,021	29,993
	Principal Streams				
	Headwater Flood	5,470	6,314	7,791	9,835
	Backwater Flood	1,659	1,998	2,842	3,578
	Total	20,273	25,717	34,654	43,406
6	Upstream Watersheds	14,457	19,999	25,971	31,577
	Principal Streams				
	Headwater Flood	3,536	4,559	5,087	5,272
	Backwater Flood	0	0	0	0
	Total	17,993	24,558	31,058	36,849
7	Upstream Watersheds	3,150	4,591	5,992	8,124
	Principal Streams				
	Headwater Flood	1,683	1,945	2,774	4,084
	Backwater Flood	623	686	835	949
	Total	5,456	7,222	9,601	13,157

Table 6 - Projected Average Annual Flood Damages-Regional Development Growth, Lower Mississippi Region (con.)

Planning Area	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
8	Upstream Watersheds	4,316	5,193	7,584	11,141
	Principal Streams				
	Headwater Flood	996	1,318	2,078	3,410
	Tidal Flood	3	5	7	11
	Miss. River (BW)				
	Flood	19	24	29	36
	Total	5,334	6,540	9,698	14,598
9	Upstream Watersheds	9,125	10,470	13,461	16,130
	Principal Streams				
	Headwater Flood	1,432	1,824	2,168	2,547
	Tidal Flood	3,292	3,683	4,443	5,368
	Miss. River (BW)				
	Flood	64	82	102	147
	Total	13,913	16,059	20,174	24,192
10	Upstream Watersheds	5,296	6,362	8,764	11,100
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	24,238	34,315	53,483	82,166
	Total	29,591	40,752	62,365	93,434
REGION TOTALS					
	Upstream Watersheds	111,089	145,747	195,846	249,205
	Principal Streams				
	Headwater Flood	68,891	95,003	119,069	164,780
	Backwater Flood	5,396	6,674	9,336	11,414
	Tidal Flood	27,533	38,003	57,933	87,545
	Total	212,909	285,427	382,184	512,944



WRPA 1

W R P A 1

DESCRIPTION

General

WRPA 1 consists of the main line levees and the area within the Mississippi River floodway below Cairo, Illinois, where main line levees are present. Where no levees are present, WRPA 1 extends only to the Mississippi River top banks (see figure 4). Approximately 2,435 square miles are included in WRPA 1 over a total length of 966 miles of river, with approximately 575 square miles of the area being composed of water surface at low flow.

Topography

WRPA 1 is composed entirely of Mississippi River alluvial lands lying in the floodway of the present channel of the Mississippi River; consequently, flooding over much of the WRPA is an annual occurrence.

Climate

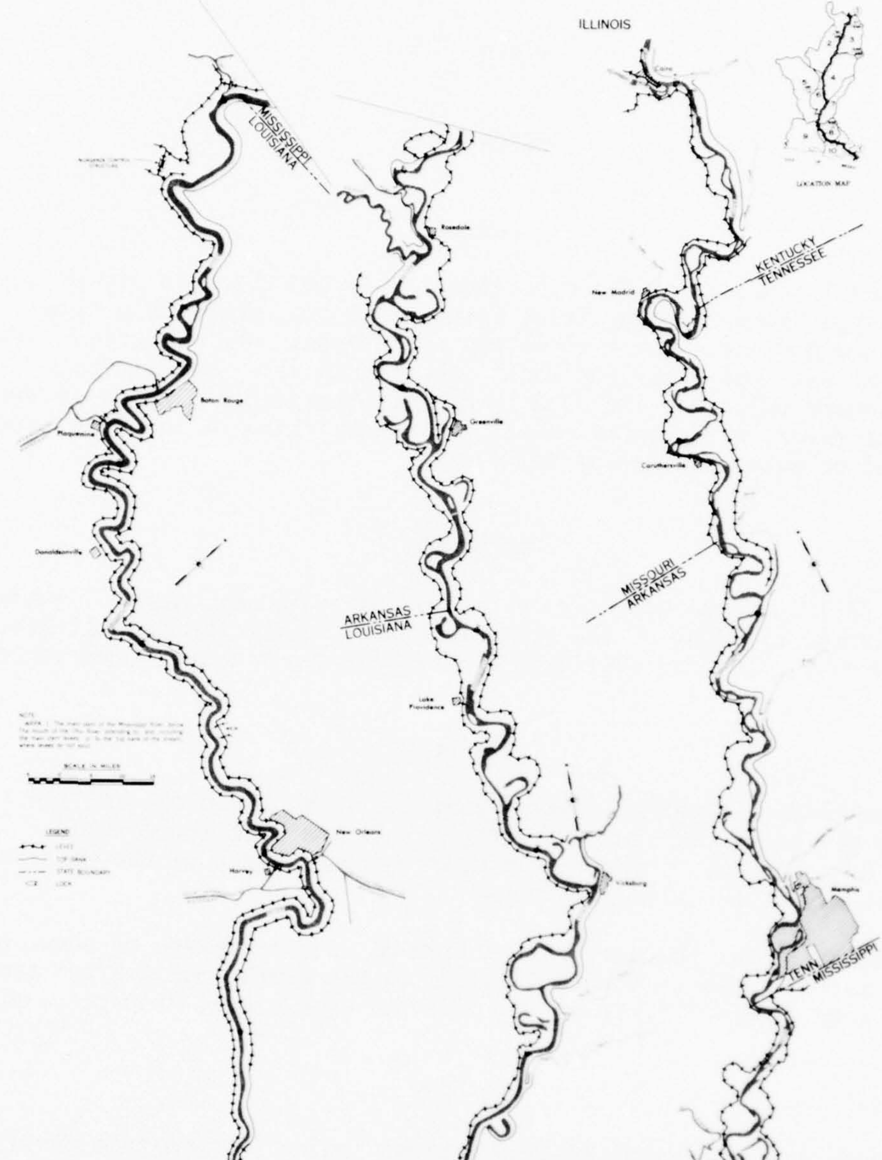
The climate of WRPA 1 varies from the warm, humid area of the Gulf of Mexico at its southern extremity to the warm summer-cold winter area near its northern tip near the confluence of the Mississippi and Ohio Rivers at Cairo, Illinois.

Rainfall over the area varies from an annual average of about 60 inches in the south to about 50 inches in the north, and average temperatures vary from 70° F. to 60° F. over the same areas, respectively.

Economy

An estimated several hundred persons reside in camp-type dwellings in WRPA 1. For practical purposes, this population was included with the populations of adjacent WRPA's.

Agricultural pursuits and waterborne transportation along the Mississippi River constitute the significant activities operating in the WRPA; however, the economic benefits produced by these activities are accounted for in other areas. The Mississippi River, which carries the largest tonnage of any waterway in the United States, contributes significantly to the region and the Nation. The river further contributes to the economic development of the region by its role of providing water to municipalities and industries in adjacent WRPA's.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 1

FIGURE 4

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in WRPA 1 is primarily headwater flooding from the Mississippi River, which with a drainage area of about 1,245,000 square miles has a wide range of flow, varying from less than 100,000 c.f.s. to more than 2,000,000 c.f.s. Flooding throughout the WRPA is frequent, occurring almost annually with the spring flows, which are fed by rainfall and snowmelt in the upper regions.

Major Historical Floods

The floods of 1913, 1927, 1937, 1950 and 1973 are known as five of the worst floods of this century in the Lower Mississippi Valley. All five of these floods completely inundated the floodway in WRPA 1 and vast areas of practically every other WRPA in the Lower Mississippi Region. Due to the fact that WRPA 1 is composed primarily of the Mississippi River floodway and flooding is expected throughout the area, most of the damages from the great floods occurred in WRPA's other than WRPA 1, and descriptions of damages from those floods appear in the respective WRPA summaries.

Existing Flood Damage Prevention Program

WRPA 1 in general is unprotected from flood damages. Most of the flood control work performed in WRPA 1 is intended for protection of adjacent WRPA's; however, WRPA 1 is largely protected from the drastic channel-altering effects of floods which have historically prevailed on unprotected reaches of the Mississippi River. A small amount of protection is inherently provided in the lowering of river stages by channel improvement along the main stem, and flood control reservoirs in the upper reaches of the Mississippi River and its tributary streams.

Structural Program

The structural improvements affecting WRPA 1 consist of revetments which prevent bank caving which leads to channel meandering, dikes which stabilize flow in the channel, preventing scouring of the riverbanks, and levees and floodwalls which effectively "wall in" floodwaters to protect areas outside WRPA 1. Additional channel improvement is provided by construction dredging which straightens and deepens the channel. These structural improvements are summarized in table 7.

Pumping stations located at areas presenting serious drainage problems behind the main stem levees pump interior drainage from adjacent WRPA's into WRPA 1. Due to their protection of adjacent WRPA's, these pumping stations are tabulated in the applicable WRPA summaries.

Land Treatment

Presently 212,000 acres in WRPA 1 are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Additional data on land use and land treatment are included in the Land Resources Appendix.

Flood Forecasting

Flood forecasting for the Mississippi River main stem from Cairo, Illinois, to New Orleans, Louisiana, is conducted by the NOAA's River Forecast Center located at Slidell, Louisiana. Additionally, the NWS offices at Memphis and New Orleans publish daily a river summary and forecast for WRPA 1.

Remaining Flood Problems

Current flood problems in terms of acres subject to flooding and average annual damages due to flooding are presented in table 8.

Table 7 - Summary of Protection Projects, 1970, WRPA 1

Channel Improvement	
a. Dredging	As required throughout 954 miles of channel
b. Bank Stabilization	954 miles 1/
c. Levees and Floodwalls	1,525 miles

1/ Includes revetments, dikes, and foreshore protection.

Table 8 - Remaining Flood Problems, Existing Conditions, WRPA 1

Area Subject to Flooding (1,000 Acres)	Average Annual Flood Damages ($1,000)			
	Agricultural	Urban & Built-up	Other	Total
1,190	2799.5	20.0	416.2	3235.7

FUTURE DAMAGES

General

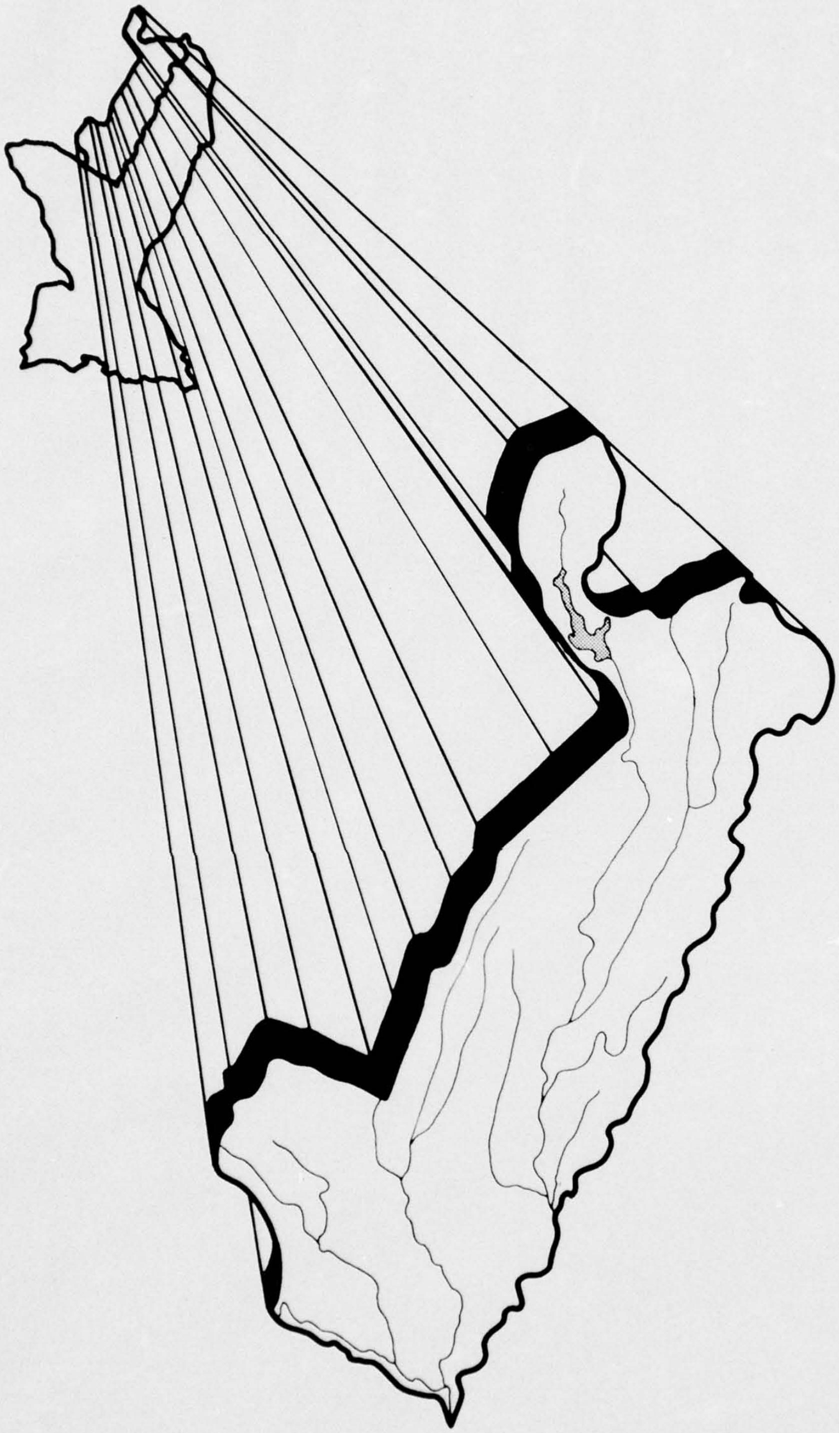
Future flood damages are evaluated for both the National Income and Regional Development objectives. The projected damage levels for both objectives are presented in tables 9 and 10 for base year (1970) and the target years of 1980, 2000, and 2020. Detailed explanations of the alternative objectives and corresponding economic projections may be found in the Economics Appendix.

Table 9 - Existing and Projected Average Annual Flood Damages National Income Growth ($1,000), WRPA 1

1970	1980	2000	2020
3,236	3,929	4,470	5,119

Table 10 - Existing and Projected Average Annual Flood Damages Regional Development Growth ($1,000), WRPA 1

1970	1980	2000	2020
3,236	4,423	4,962	5,754



WRPA 2

W R P A 2

DESCRIPTION

General

WRPA 2 comprises an area of 16,723 square miles in southeastern Missouri, and northeastern Arkansas (see figure 5). The area is bounded on the east by the Mississippi River, on the north by the Castor River diversion channel, the upper Castor River drainage basin and the Meramec River Basin, on the west by the White River Basin to Augusta, Arkansas, and on the south by the Arkansas River right bank levee from Pine Bluff to the Mississippi River main stem levee.

Topography

The terrain in primarily composed of alluvial lands bounded by foothills on the north and west and major rivers on the south and east. A notable exception is Crowley's Ridge, a line of hills extending from the Ozark foothills near Poplar Bluff, Missouri, to the Mississippi River near Helena, Arkansas. Elevations vary from 150 feet m.s.l. in the south to 1,750 feet m.s.l. in the north.

The landscape consists of prairies which are extensively farmed, lowlands which are usually forested with bottomland hardwoods, and rolling uplands that are managed to varying degrees for agricultural production.

Major drainage areas in the WRPA include the St. Francis Basin, St. John's Bayou-New Madrid Floodway, and portions of the Arkansas and White Basins. For planning purposes, these areas were broken down into nine basins as shown in figure 5.

The St. Francis River Basin is the largest drainage area completely contained within the WRPA. The St. Francis River rises in the rugged Ozark hill region of southeastern Missouri and flows in a winding, often deteriorating channel 475 miles to enter the Mississippi River at Mile 670 near Helena, Arkansas. In many locations, low water and flood flows are forced into artificial channels formed by old levee borrow pits. Below Wappapello Dam, located in the edge of the Ozarks, the river traverses a partially leveed floodway to the gap in Crowley's Ridge. Below Crowley's Ridge, the river flows through a leveed floodway and a combination natural-artificial channel complex, south to its confluence with the Mississippi River. The St. Francis Basin is divided into three major subbasins, Upper St. Francis, Little River, and Lower St. Francis, as shown in figure 5.

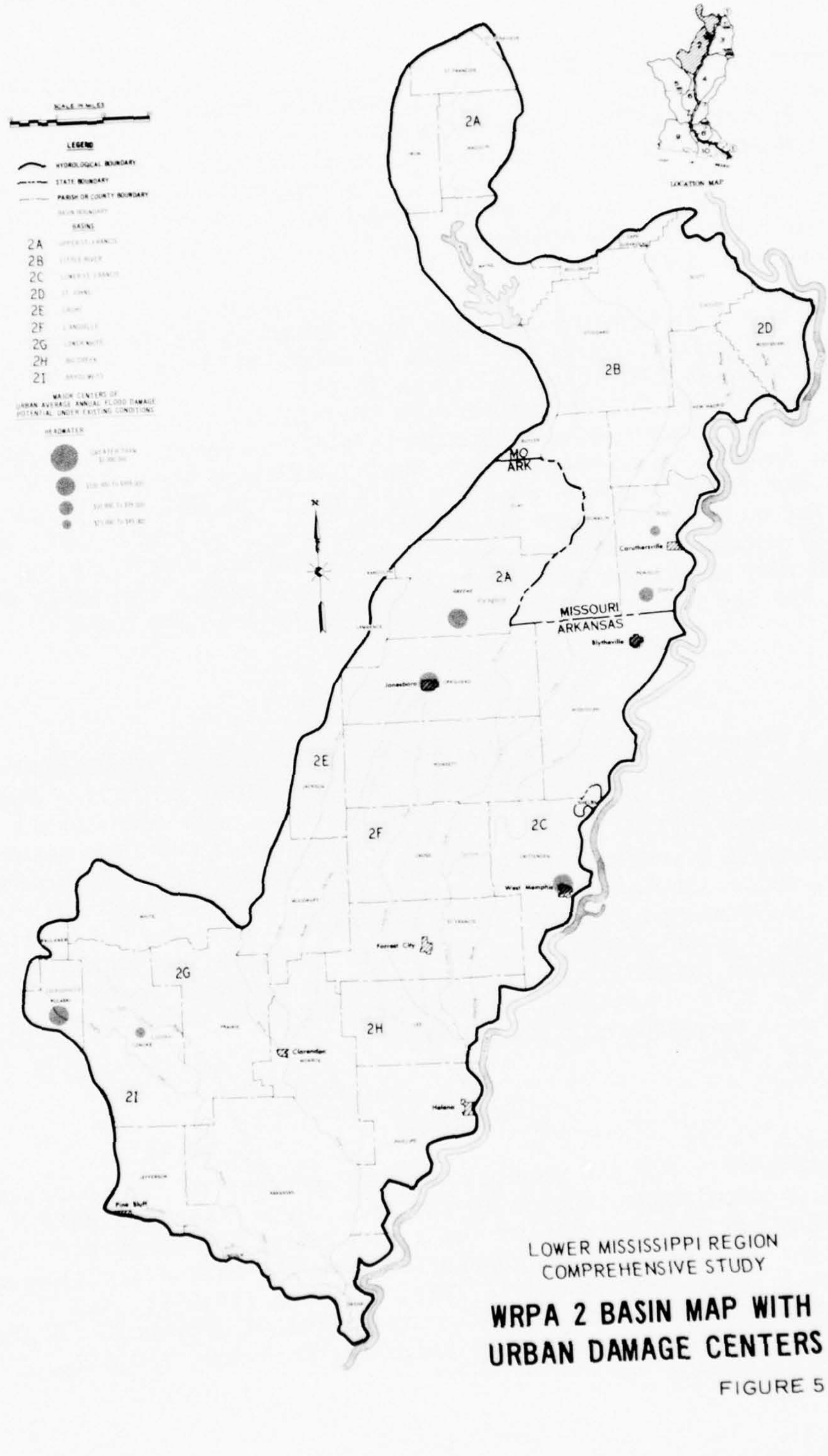
The St. John's Bayou area is a relatively small drainage area comprising 480 square miles of Mississippi River alluvial land which is practically devoid of relief, creating major drainage problems.

The Cache River Basin is drained by two major tributaries, Cache River and Bayou DeView, and has a total drainage area of 2,025 square miles. Cache River, which is the largest of the White River tributaries in the lower basin, rises in Butler County, Missouri, and flows southwesterly 213 miles to enter the White River just above Clarendon, Arkansas. Above Pitts, Arkansas, the natural channel has been replaced by straightened artificial channels, but below that point the river follows a sinuous course through a floodplain which is largely timbered. Bayou DeView, principal tributary to the Cache River, originates in Crowleys Ridge near Jonesboro, Arkansas, and flows southwesterly, entering the Cache River at Mile 10. It too, in its upper reaches above Mile 43, has been developed as an artificial channel. In its lower reaches the channel is poorly defined and consists of disconnected pools and swales.

The L'Anguille River Basin encompasses 942 square miles of hill and floodplain lands. L'Anguille River rises on Crowley's Ridge near Jonesboro, Arkansas, and flows southeasterly for 107 miles to join the St. Francis River channel about 17 miles upstream from the Mississippi River. The stream is developed as an artificial channel above the Poinsett-Cross County line (Mile 86) below which the natural channel follows a twisting course through a timbered floodplain up to 1.5 miles in width. This floodplain lies 2 to 5 feet below the general ground elevation of the flat tableland of the valley.

The Lower White River Basin in WRPA 2 includes the lower 169 miles of the river and its tributary area below Peach Orchard Bluff near Georgetown, Arkansas. The alluvial valley portion of the basin is generally a gently undulating plain about 150 feet above mean sea level and its southern tip and rising northerly at about two-thirds of a foot per mile. Tributary streams flow sluggishly through broad, shallow valleys in winding channels approximately parallel to the main stream. The bottomlands are characterized by numerous swamps, bayous, lakes, and abandoned stream channels. The interstream areas have elevations ranging from a few feet to 35 or 40 feet above the stream channels. The higher elevations consist of low disconnected areas which are generally parallel to the valley slope.

The Big Creek drainage basin encompasses 1,060 square miles. The Big Creek channel follows a sinuous course some 90 miles from its source near the Woodruff-St. Francis County, Arkansas, line to join the White River about 52 miles upstream from the Mississippi River. The floodplain of the stream is generally wooded throughout and varies from 1/4 mile to 5 miles in width. The Big Creek Basin is drained by 12 tributaries to Big Creek in addition to the Big Creek channel proper.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 2 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 5

These tributaries have drainage areas varying from 34 to 138 square miles.

Bayou Meto Basin is located in the east and central portions of the State of Arkansas. It occupies portions of Faulkner, Pulaski, Lonoke, Prairie, Jefferson, and Arkansas Counties. The total drainage area is about 1,030 square miles, of which 180 square miles are pronounced hill lands, and the remainder is generally flat. The basin is the drainage outlet of the lands bounded by the White River drainage system on the north and northeast and by the Arkansas system on the south and southwest.

The upper portion of the Bayou Meto Basin is in the eastern limits of the Ozark uplift. Here the basin is rough and hilly. The more extensive lower portion of the basin is in the broad alluvial valley of the Arkansas River, which merges with that of the Mississippi River floodplain well upstream from the mouth of Bayou Meto. The large alluvial section of the Bayou Meto Basin comprises three general divisions. The first division consists of a small gently rolling plain area. The second, known as the Grand Prairie, is a level plain made up of an old second bottom or terrace of the Arkansas River, rising from 10 to 30 feet above the first bottom of that stream. The third division is the low bottom area immediately adjacent to the bayou.

Climate

The climate of WRPA 2 is characterized by fairly cold winters and hot summers, with the extreme months, January and July, having mean temperatures of 40° F. and 80° F., respectively. The mean annual temperature of the region is 60° F., with an average frost-free growing season of about 7 months. Rainfall in the area averages 50 inches annually, which combined with the temperatures of the region produces a typical subtropical climate. Tropical storms from the Gulf of Mexico produce some violent weather periods in the WRPA during the hurricane season. Though the tropical storms lose much of their force before reaching the area, tornadoes, high winds, and heavy rainfall occur in the WRPA as a by-product of these storms.

Economy

Approximately 626,690 people, about 10 percent of the Lower Mississippi Region population, reside in the area which comprises WRPA 2. Urban population as a percent of total population was 40 percent in 1970. Major centers of urban population were the Missouri cities of Charleston (5,131), New Madrid (2,719), Sikeston (14,699), and Caruthersville (7,350), and the Arkansas cities of Jonesboro (27,050), Blytheville (24,752), Forrest City (12,521), Paragould (10,639),

Stuttgart (10,477), Helena (10,415), West Helena (11,007), and Marianna (6,196). Population is projected to increase to 795,000 in 2020 under the National Income objective and to 925,000 in 2020 under the Regional Development objective. The population will be more urbanized in 2020 with 64 percent of the total population located in cities.

Significant economic activities in the area include agriculture, mining, manufacturing, and service industries. The major manufacturing categories are food and kindred products, primary metals, chemical and allied products, and textile mill products. The 1968 manufacturing gross product was $320 million and is expected to increase to $3.4 billion under the National Income objective and $4.9 billion under the Regional Development objective by 2020.

Another significant segment of the area's economy is agriculture. Major agricultural pursuits include production of soybeans, rice, corn, wheat, and cotton. In 1970 agricultural gross product was $680 million with the 2020 projections being $1.026 billion under the National Income objective and $1.100 billion under the Regional Development objective.

Land use in the planning area, a total of 10,702,000 acres, consists of cropland, 56 percent; pasture, 3 percent; forests and woodlands, 25 percent; urban and built-up lands, 3 percent; water areas, 2 percent; and other lands, 11 percent. Urban lands are expected to increase by more than 25 percent by 2020.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Floods are generally caused by rainstorms lasting several days and moving northeastward across the area. These storms occur most frequently from January to May. Flooding in the area may be categorized into two distinct types of flooding which may occur singly or in combination.

Backwater Flooding

Lands adjacent to the Mississippi River tributaries are subject to flooding due to high stages in these rivers as a result of high stages in the Mississippi River, which causes floodwaters to back into the tributary basins and flood adjacent lands.

Lands adjacent to the White River and Arkansas River are also subject to flooding due to high stages caused by excessive rainfall in the White River and Arkansas River Basins. The Mississippi River, White River, and Arkansas River flooding are all primarily the result of runoff originating outside the planning area.

Headwater Flooding.

Lands along most drainage arteries are subject to flooding due to high stages which are generated by runoff originating within the watershed tributary to those arteries.

Major Historical Floods

Due to the flat, alluvial plain nature of most of WRPA 2, flooding has historically posed problems on an annual or higher frequency along many of the streams which drain the WRPA. Though much work has been directed toward controlling these floods, they have continued to occur and even with flooding frequencies reduced, more intensive land uses result in increasing flood losses.

Serious flooding in WRPA 2 occurred in 1927, 1937, 1945, 1950, 1957, 1972, and 1973. These floods were caused by Mississippi River backwater, tributary flooding within the WRPA, or a combination of the two. The following descriptions of these floods include figures which depict a portion of the land flooded and dollar damages sustained.1/

1927 Flood

General heavy rainfall throughout much of the drainage basin of the Mississippi River from December 1926 to April 1927 set the stage for the "Great Flood." Specifically, a general rain from 5 to 21 April

1/ Damage figures shown are dollar damages for the year in which the flood occurred and are not corrected to 1970 dollars.

1927, which produced rainfall in excess of 7.5 inches over most of the drainage area, was the major cause of the flood of April 1927.

The "Great Flood" inundated more than 2.5 million acres and caused known damages in excess of $3.5 million in WRPA 2.

1937 Flood

This great flood resulted from practically continuous rainfall over the area from 26 December 1936 to 25 January 1937, with stations in the St. Francis River Basin recording from 15 to 20 inches of precipitation. A 9-day storm from 17 through 25 January produced rainfall averaging about 12 inches over the area.

During January and February 1937, approximately 3.5 million acres in WRPA 2 were flooded from backwater of the Mississippi River and headwater of the Mississippi River and headwater from the tributary streams. Total known damages amounted to about $3.9 million, which were 90 percent non-crop losses and 10 percent agricultural losses.

1945 Flood

A series of heavy rains from the middle of February to the first week of April 1945 helped to produce the flood of April 1945. Three major storms of 2 weeks' duration plus intervening rains produced rainfall of about 6 inches over the area, flooding approximately 1.2 million acres and causing about $2.7 million in damages.

1950 Flood

Precipitation above the average in January 1950, coupled with excessive precipitation during the first 3 weeks of February, resulted in flooding from January through March 1950. The average rainfall over the area for January and February was about 9.5 inches, second only to the 1937 record.

During the January through March flood and another less severe flood in mid-May 1950, there were approximately 1.6 million acres flooded from a combination of headwater and backwater flooding. Total damages amounted to about $4.6 million, of which 55 percent was crop damage and 45 percent was damage to rural non-crop items, railroads, highways, levees, and urban areas, plus cost of evacuation and rehabilitation.

1957 Flood

Heavy rainfall produced serious flooding in the months of April and November 1957, inundating a total of 1.3 million acres and causing about $0.9 million in damages.

1972 Flood

During the harvest season of 1972, general rains occurred almost continually over the entire WRPA, causing flooding on thousands of acres of bumper crops ready for harvest. At the time of this writing, the damages over the entire WRPA are not available, but along the Cache River alone crop damages exceeded $4.5 million, and many millions of dollars additional damages occurred in the St. Francis Basin, with the Missouri bootheel being particularly hard hit.

Though the floods described herein were recorded as some of the major historical hydrologic events, many damaging floods, too numerous to detail here, have occurred frequently on practically every one of the tributary rivers and streams of the WRPA.

Flooded cropland, Cache River Basin, Arkansas, December 1972.

1973 Flood

On 20 March 1973, the Mississippi River rose out of its banks and began the longest-duration flood ever faced by residents of much of WRPA 2. Federal, state, and local flood-fighting capabilities were mobilized and began an arduous, often dramatic effort to control this flood. These efforts were successful in that all major flood control structures were held intact, however, large areas of unprotected land were flooded as backwater covered much of the Birds Point-New Madrid Floodway in Missouri and the lower St. Francis and White Rivers' basins in Arkansas. Altogether, backwater inundated 474,000 acres in WRPA 2 at a loss of $40 million.

In terms of flood heights, the 1973 flood on the Mississippi River bordering this WRPA was between a 10 to 25-year frequency flood and the flood heights were as much as eight feet below the stages of the record flood of 1937 and 12 feet below project flood levels. The area flooded was correspondingly far less than under those floods despite the fact that the record 63 days' duration of the 1973 flood produced more total volume of runoff than any recorded previous flood. This record duration of flooding proved to be disastrous to those areas which were inundated.

Mississippi River floodwaters were not the only source of flooding in WRPA 2 during this period. Unseasonably heavy rainfall occurring over the already-saturated soil produced severe headwater flooding along many of the area's tributary streams, particularly in the St. Johns basin in Missouri and along the St. Francis and White Rivers in Arkansas.

Following the flood, damages in WRPA 2 proved to be high with total estimated damages of $108.3 million occurring over the 1,114,000 acres that were inundated.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed flood control improvements that prevent much of the potential damage from headwater and backwater flooding of the Mississippi River and its major tributary systems. The main line levee system of the Mississippi River is outlined in the WRPA 1 summary, while other Federally-sponsored improvements are enumerated in tables 11 and 12. Due to their random nature, extensive improvements which have been constructed by local interests alone cannot be summarized here. More detailed information on all flood control improvements may be found in the Inventory of Facilities Appendix. Information on projects and studies currently underway along with Federal agency authorities are contained in Appendix T, Plan Formulation.

In the St. Francis River Basin, lands receiving protection are located along both the St. Francis and Little River drainage areas. Flood control improvements in the existing program are directed toward reduction of damages produced by both headwater and backwater flooding. The flood control structures for the streams consist of combinations of levees, channel improvements, pumping stations and flow retarding structures such as those utilized in the smaller, individual watershed projects in the basin. Additionally, local interests have constructed almost innumerable small drainage improvements which provide protection to much of the basin's area.

A major reduction in damages in the St. Francis River Basin will be effected by completion of the 12,000 cfs, W.G. Huxtable Pumping Plant which is under construction near the mouth of the St. Francis River.

The Cache River Basin in WRPA 2 is currently undergoing extensive flood damage mitigation measures. When completed, these improvements will concurrently enhance the agricultural production of the basin and provide habitat for the basin's wildlife.

Other structural measures in WRPA 2 include levees and pumping stations around towns along the lower White River, and the Arkansas River levees which protect the grand prairie region of Arkansas.

Table 11 - Flood Control Storage, 1970, WRPA 2 1/

Basin	Major Reservoir	Small Reservoir	Totals
	Flood Control - Storage in 1,000 Acre-Feet		
Upper St. Francis	582	9.4	591.4
Little River	0	0	0
Lower St. Francis	0	5.2	5.2
St. Johns	0	0	0
Cache	0	16.9	16.9
L'Anguille	0	3.8	3.8
Lower White	0	13.6	13.6
Big Creek	0	0	0
Bayou Meto	0	0	0
Total	582	48.9	630.9

1/ Additional storage exists in tributary regions, lowering stages on Arkansas and White Rivers and aiding forecasting.

Table 12 - Summary of Local Protection Projects, 1970, WRPA 2 1/

Basin	Levees (Miles)	Channel Improvement 2/ (Miles)	Bank Stabilization (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Upper St. Francis	183.0	95.8	0	0	0
Little River	130.1	177.0	0	0	0
Lower St. Francis	116.1	278.2	1.8	2	12,330
St. Johns	12.1	0	0	0	0
Cache	0	63.5	0	0	0
L'Anguille	0	86.9	0	0	0
Lower White	85.9	176.1	0.3	3	1,670
Big Creek	0	110.0	0	0	0
Bayou Meto	141.6	0	39.0	0	0
Total	668.8	1,563.1	41.1	5	14,000

1/ Consists of projects in both upstream watersheds and principal reaches.
2/ Channel improvement for navigation not included.

Nonstructural Program

Flood Plain Information studies and reports and technical assistance are provdied to urban areas for use in management of floodplains. The local governments may then utilize several approaches to floodplain management such as zoning ordinances, subdivision regulations, construction codes, and flood-proofing of existing structures. In WRPA 2, six Flood Plain Information reports have been completed or are underway.

Flood Insurance studies are conducted to provide a basis for rate determination and issuance of flood insurance. These studies constitute another source of floodplain information, and presently two such studies are completed or are underway in WRPA 2.

Land Treatment

Presently 3,594,000 acres in WRPA 2 are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Data on acres with adequate treatment by basin are shown in table 13. Additional data on land use and land treatment are included in the Land Resources Appendix.

Graham Burke Pumping Plant and Little Island Bayou Drainage Structure, Lower White River Arkansas.

Table 13 - Land Treatment, 1970, WRPA 2

Basin	Lands Adequately Treated Acres (1,000's)
Upper St. Francis	662
Little River	164
Lower St. Francis	553
St. Johns	127
Cache	563
L'Anguille	288
Lower White	566
Big Creek	240
Bayou Meto	431
Total	3,594

Flood Forecasting

River and flood forecast service is provided by the National Weather Service offices at Memphis, Tennessee, and Little Rock, Arkansas. Forecast dissemination is largely provided via the news media through the use of the NOAA Wire Service, a teletypewriter network available to all bona fide mass news disseminators.

Emergency Operations

The Federal Government and State and local agencies have cooperated on numerous occasions when natural disasters have befallen the area. Emergency operations performed in the past have included evacuations and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and recovery operations.

Remaining Flood Problems

The major flood problems remaining in WRPA 2 are the results of inundations from storms and subsequent stream overflows. Remaining Mississippi River backwater flooding problems exist in the St. Francis and Lower White River basins and in the St. Johns area. When projects currently under construction are completed, this type of flooding will be essentially eliminated in the St. Francis Basin; however, it will remain a problem in the Lower White River Basin. The St. Johns area, which includes the Birds Point-New Madrid Floodway, will also remain subject to flooding by Mississippi River backwater which enters the floodway through the drainage gap left in the main line levee at the lower end of the floodway. Throughout the WRPA, a total of about 261,000 acres

Flooded farmland near Kennett, Missouri, 1967.

Flooded soybeans near Marianna, Arkansas,
after a 2-1/2-inch rain.

are subject to flooding by Mississippi River backwater.

Headwater flooding in WRPA 2 is prevalent in all basins of the area from the myriad of tributary streams which crisscross the area. The upper St. Francis Basin experiences headwater flooding from just below Wappapello Lake, south to the junction of the St. Francis and Little Rivers. This flooding, both along the banks of the St. Francis and its tributary streams in this reach, has an estimated potential of inundating 613,000 acres, which causes heavy agricultural damages and floods several urban areas such as Paragould, Arkansas.

The Little River Basin, a very flat alluvial area which historically has been difficult to drain due to its topography, is subject to extensive headwater flooding. Altogether, almost 1.5 million acres in this basin are subject to inundation at an average annual potential loss of about $9.0 million in both agricultural and urban damages.

The Lower St. Francis River, aided by the flow from the Little River Basin, has a maximum headwater flood potential of about 1.1 million acres. This flooding occurs both along the St. Francis and along its major tributaries such as the Tyronza River and Blackfish Bayou. This headwater flooding has a damage potential of more than $8.2 million in average annual damage.

In the St. Johns Basin, headwater flooding subjects 214,000 acres to inundation from St. Johns Bayou, St. James Bayou, and their tributaries. This flooding causes average annual damages estimated at more than $3.0 million, primarily in agricultural losses.

The Cache River basin with its long, narrow configuration and the presence of both Cache River and Bayou DeView in the basin, is subject to and suffers frequent losses from headwater flooding from these streams and their tributaries. Nearly 1.25 million acres are subject to flooding in this area and potential average annual damage is above $4.5 million. The flood potential in this basin was drastically emphasized by the damaging floods which occurred over much of the area in 1972.

Lands bordering the L'Anguille River and tributaries are subject to overflow with a total headwater flooding potential from all sources of about 420,000 acres. The potential average annual damages in this basin are about $3.8 million.

The Lower White Basin and Big Creek Basin, a major tributary of the Lower White, are largely unimproved against flooding. As a result, about 1.7 million acres are subject to flooding in the two basins, resulting in potential average annual damages of almost $11.7 million.

Bayou Meto, tributary to the Lower Arkansas River, is a major source of headwater flood damages in WRPA 2. Due to the development level in the Bayou Meto Basin, the 686,000 acres subject to headwater flooding experience potential average annual damages of nearly $11.3 million.

Table 14 contains an explicit breakdown of acreage subject to flooding and average annual dollar damage levels in principal stream reaches and upstream watersheds.

Table 14 - Remaining Flood Problems, Existing Conditions (1970), WRPA 2

Basin	Area Subject to Floods (1,000 Acres)		Average Annual Damages Due To Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total
Upper St. Francis														
Headwater Flood	382	231	4,475	47	277	4,799	2,451	0	332	2,783	6,926	47	609	7,582
Little River														
Headwater Flood	1,146	347	2,807	106	518	3,431	4,768	137	617	5,522	7,575	243	1,135	8,953
Lower St. Francis														
Headwater Flood	934	194	2,317	888	1,011	4,216	3,486	0	546	4,032	5,803	888	1,557	8,248
Backwater Flood	368	0	167	0	41	208	0	0	0	0	167	0	41	208
St. Johns														
Headwater Flood	118	96	1,038	8	62	1,108	1,716	0	190	1,906	2,754	8	252	3,014
Backwater Flood	74	0	22	0	5	27	0	0	0	0	22	0	5	27
Cache														
Headwater Flood	708	531	1,745	121	255	2,121	2,073	0	360	2,433	3,818	121	615	4,554
L'Anguille														
Headwater Flood	129	290	113	9	12	134	3,228	0	447	3,675	3,341	9	459	3,809
Backwater Flood	21	0	18	0	6	24	0	0	0	0	18	0	6	24
Lower White														
Headwater Flood	653	240	5,458	10	702	6,170	2,270	3	397	2,670	7,728	13	1,099	8,840
Backwater Flood	378	0	102	0	18	120	0	0	0	0	102	0	18	120
Big Creek														
Headwater Flood	443	356	737	0	149	886	1,664	0	275	1,939	2,401	0	424	2,825
Backwater Flood	20	0	146	0	10	156	0	0	0	0	146	0	10	156
Bayou Meto														
Headwater Flood	345	331	1,439	213	887	2,539	7,576	0	1,166	8,742	9,015	213	2,053	11,281
WRPA TOTALS														
Headwater Flood	4,858	2,616	20,129	1,402	3,873	25,404	29,232	140	4,330	33,702	49,361	1,542	8,203	59,106
Backwater Flood	861	0	455	0	80	535	0	0	0	0	455	0	80	535
TOTAL						25,939				33,702				59,641

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections, while the Regional Development objective is based on a slightly higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources.

Projected land use indicates that further urban and agricultural development will take place in the floodplains. Future use of lands in the floodplains is expected to be about the same under either the National Income or the Regional Development objective. Urban development, however, is expected to be slightly more rapid under the Regional Development objective.

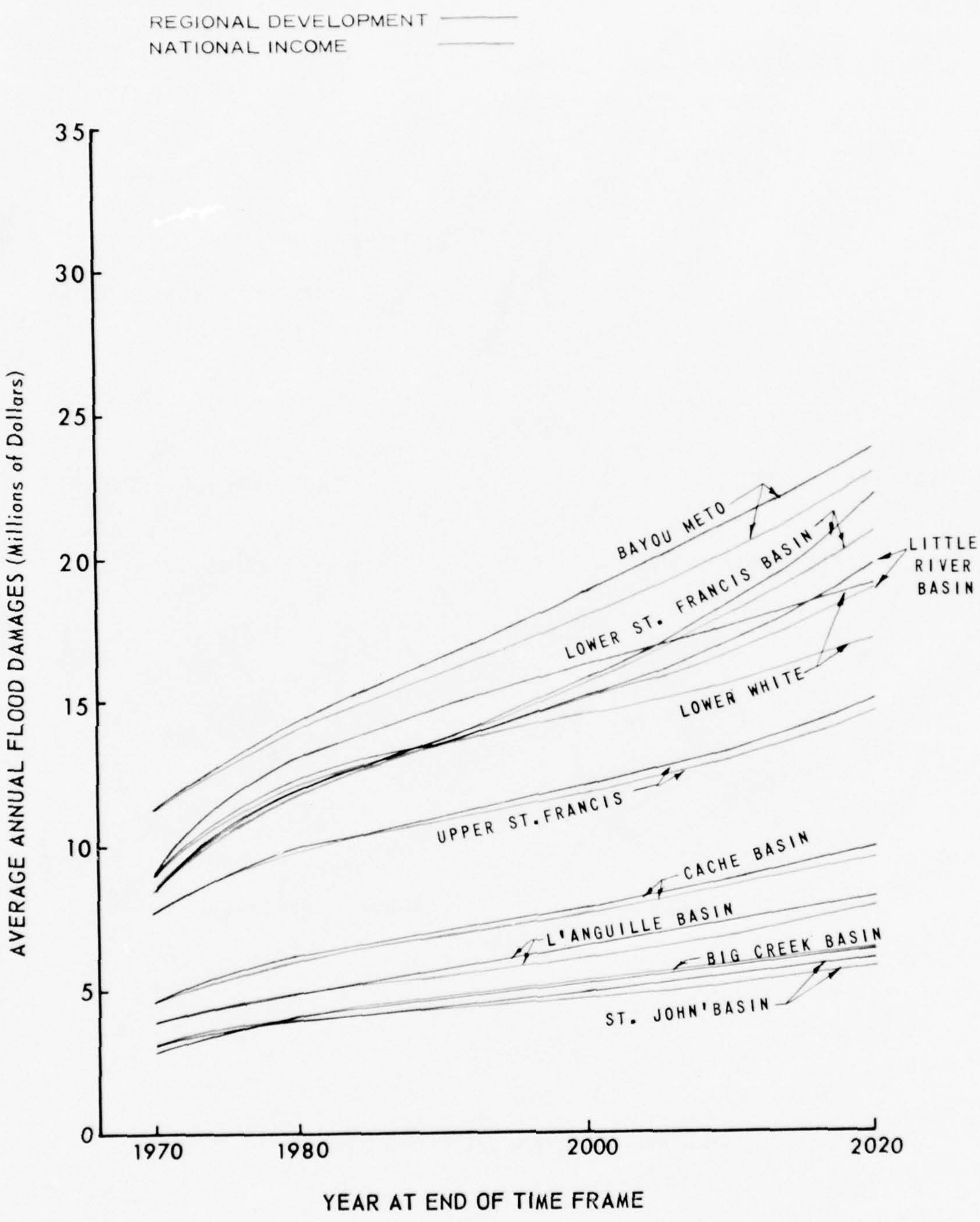
The distribution of damages by type for each of the two objectives is shown in figure 6 for the years 1970 and 2020. Figure 7 illustrates the trends and relative magnitudes of future damages. Additional details on the alternative levels of economic development are contained in the Economics Appendix.

Future Flood Damages with National Income Growth Rate

The level of average annual flood damages in WRPA 2 on all streams and including Mississippi River backwater is shown in table 15, which lists base year (1970) and projected levels of average annual damages by principal drainage basins and causes. The estimates of future damage levels are based on economic and land use projections for the National Income objective in the Economics Appendix and the Land Resources Appendix.

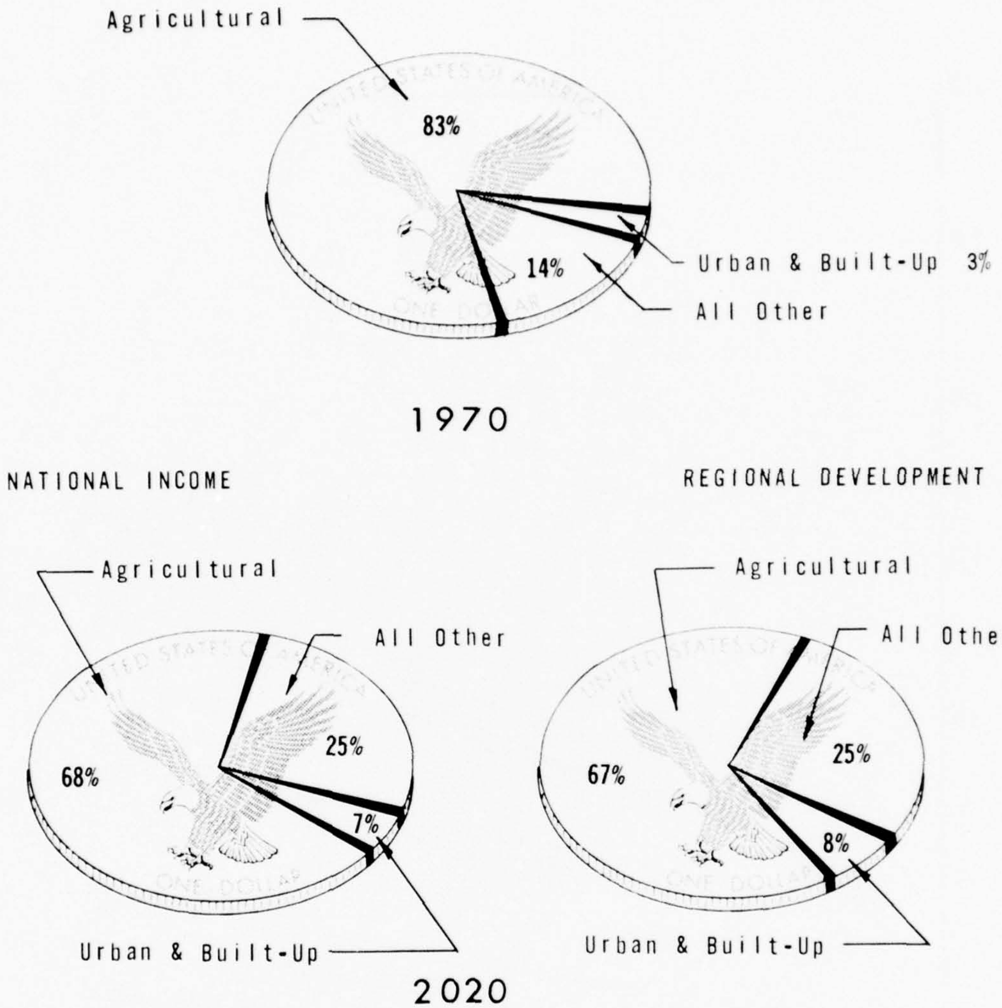
Future Flood Damages with Regional Development Growth Rate

Estimated future flood damages under the Regional Development objective are listed in table 16. Future flood damages under this objective will be of the same order of magnitude as those estimated for the National Income objective. The magnitudes of rural damages are essentially the same for both objectives, while urban damages show an increase under the Regional Development objective. Standard Project flood occurrence on the Mississippi River would produce the same level of damages under either objective.



PROJECTED AVERAGE ANNUAL DAMAGE - WRPA-2

Figure 6



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-2

Figure 7

Table 15 - Projected Average Annual Flood Damages, National Income Growth, WRPA 2

Basin	Delineation	Average Annual Damage ($1,000) 1970	1980	2000	2020
Upper St. Francis	Upstream Watersheds	2,783	3,482	4,416	5,646
	Principal Streams				
	Headwater Flood	4,799	6,477	7,428	9,088
	Backwater Flood	0	0	0	0
	Total	7,582	9,959	11,844	14,734
Little River	Upstream Watersheds	5,522	6,734	8,512	10,836
	Principal Streams				
	Headwater Flood	3,431	5,553	6,581	8,163
	Backwater Flood	0	0	0	0
	Total	8,953	12,287	15,093	18,999
Lower St. Francis	Upstream Watersheds	4,032	5,054	6,480	8,407
	Principal Streams				
	Headwater Flood	4,216	6,447	8,721	12,161
	Backwater Flood	208	265	369	413
	Total	8,456	11,766	15,570	20,981
St. Johns	Upstream Watersheds	1,906	2,379	2,977	3,737
	Principal Streams				
	Headwater Flood	1,108	1,566	1,738	2,005
	Backwater Flood	27	35	39	42
	Total	3,041	3,980	4,754	5,784
Cache	Upstream Watersheds	2,433	3,054	3,949	5,179
	Principal Streams				
	Headwater Flood	2,121	3,120	3,672	4,467
	Backwater Flood	0	0	0	0
	Total	4,554	6,174	7,621	9,646
L'Anguille	Upstream Watersheds	3,675	4,600	5,841	7,486
	Principal Streams				
	Headwater Flood	134	187	226	289
	Backwater Flood	24	33	38	44
	Total	3.833	4,820	6,105	7,819
Lower White	Upstream Watersheds	2,670	3,347	4,340	5,701
	Principal Streams				
	Headwater Flood	6,170	8,591	10,145	11,350
	Backwater Flood	120	155	176	199
	Total	8,960	12,093	14,661	17,250

Table 15 - Projected Average Annual Flood Damages, National Income Growth, WRPA 2 (con.)

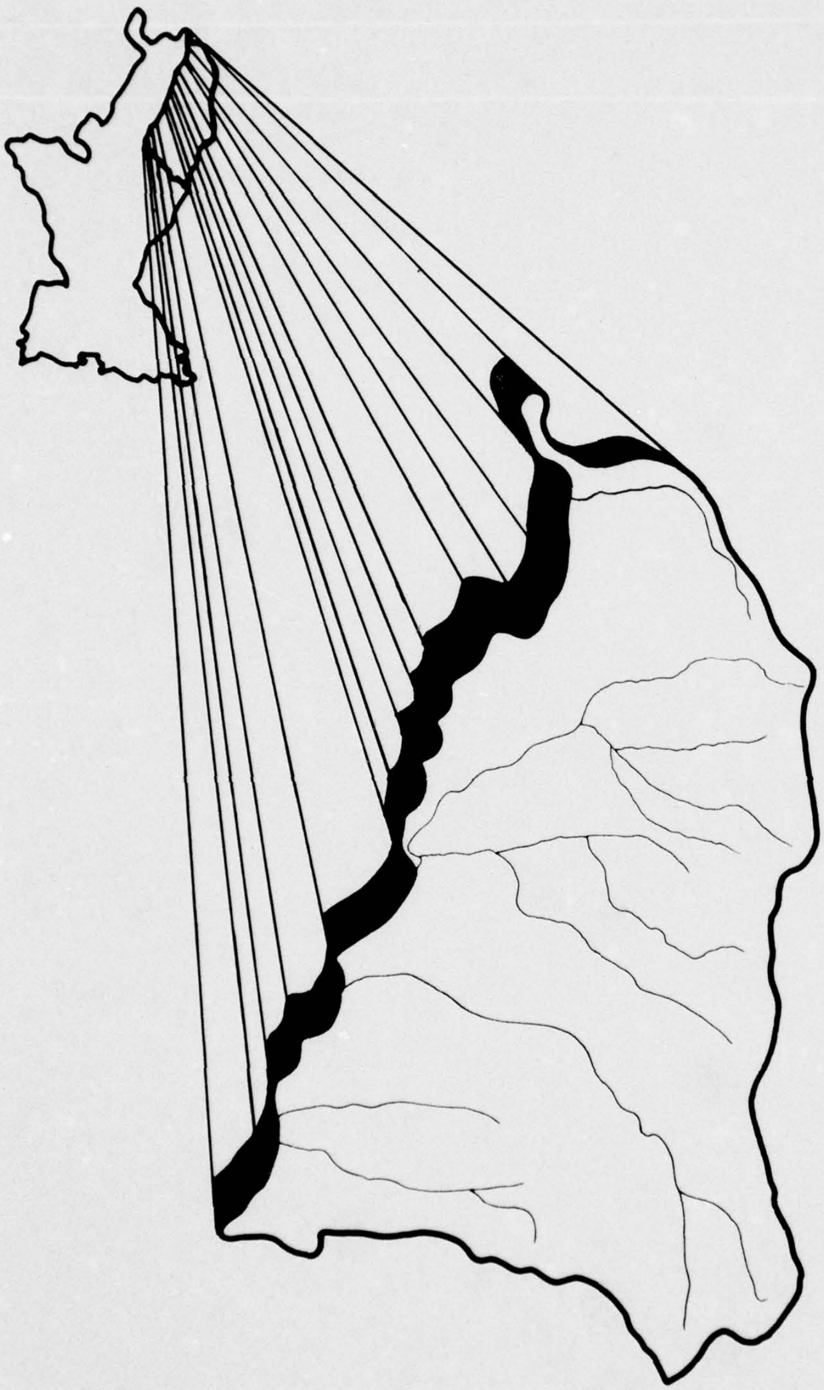
Basin	Delineation	Average Annual Damage ($1,000) 1970	1980	2000	2020
Big Creek	Upstream Watersheds	1,939	2,432	3,132	4,086
	Principal Streams				
	Headwater Flood	886	1,360	1,544	1,746
	Backwater Flood	156	204	231	262
	Total	2,981	3,996	4,907	6,094
Bayou Meto	Upstream Watersheds	8,742	10,955	14,026	18,164
	Principal Streams				
	Headwater Flood	2,539	3,342	4,003	4,813
	Backwater Flood	0	0	0	0
	Total	11,281	14,297	18,029	22,977
WRPA TOTALS	Upstream Watersheds	33,702	42,037	53,673	69,242
	Principal Streams				
	Headwater Flood	25,404	36,643	44,058	54,082
	Backwater Flood	535	698	853	960
	Total	59,641	79,378	98,584	124,284

Table 16 - Projected Average Annual Flood Damages, Regional Development Growth, WRPA 2

Basin	Delineation	Average Annual Damage ($1,000) 1970	1980	2000	2020
Upper St. Francis	Upstream Watersheds	2,783	3,493	4,702	5,966
	Principal Streams				
	Headwater Flood	4,799	6,469	7,431	9,126
	Backwater Flood	0	0	0	0
	Total	7,582	9,962	12,133	15,092
Little River	Upstream Watersheds	5,522	6,754	9,068	11,458
	Principal Streams				
	Headwater Flood	3,431	5,582	6,071	7,769
	Backwater Flood	0	0	0	0
	Total	8,953	12,336	15,139	19,927
Lower St. Francis	Upstream Watersheds	4,032	5,072	6,892	8,865
	Principal Streams				
	Headwater Flood	4,216	6,559	8,610	13,120
	Backwater Flood	208	265	369	413
	Total	8,456	11,896	15,871	22,398
St. Johns	Upstream Watersheds	1,906	2,386	3,175	3,959
	Principal Streams				
	Headwater Flood	1,108	1,566	1,740	2,012
	Backwater Flood	27	35	39	42
	Total	3,041	3,987	4,954	6,013
Cache	Upstream Watersheds	2,433	3,065	4,196	5,454
	Principal Streams				
	Headwater Flood	2,121	3,133	3,697	4,519
	Backwater Flood	0	0	0	0
	Total	4,554	6,198	7,893	9,973
L'Anguille	Upstream Watersheds	3,675	4,615	6,220	7,908
	Principal Streams				
	Headwater Flood	134	188	231	300
	Backwater Flood	24	33	38	44
	Total	3,833	4,836	6,989	8,252
Lower White	Upstream Watersheds	2,670	3,360	4,611	6,001
	Principal Streams				
	Headwater Flood	6,170	9,952	11,703	13,108
	Backwater Flood	120	155	176	199
	Total	8,960	13,467	16,490	19,308

Table 16 - Projected Average Annual Flood Damages, Regional Development Growth, WRPA 2 (con.)

Basin	Delineation	Average Annual Damage ($1,000) 1970	1980	2000	2020
Big Creek	Upstream Watersheds	1,939	2,441	3,329	4,305
	Principal Streams				
	Headwater Flood	886	1,360	1,544	1,741
	Backwater Flood	156	204	232	261
	Total	2,981	4,005	5,105	6,307
Bayou Meto	Upstream Watersheds	8,742	10,993	14,921	19,161
	Principal Streams				
	Headwater Flood	2,539	3,342	4,003	4,813
	Backwater Flood	0	0	0	0
	Total	11,281	14,335	18,924	23,974
WRPA TOTALS	Upstream Watersheds	33,702	42,179	57,114	73,077
	Principal Streams				
	Headwater Flood	25,404	38,151	45,030	56,508
	Backwater Flood	535	692	854	959
	Total	59,641	81,022	102,998	130,544



W R P A 3

W R P A 3

DESCRIPTION

General

WRPA 3 comprises an area of 10,653 square miles and includes the extreme southern tip of Illinois, west Kentucky, west Tennessee and north Mississippi (see figure 8). The area is bounded on the west by the Mississippi River, on the north and east by the drainage divide separating the Mississippi River Basin from the Ohio and Tennessee River Basins, and on the south by a drainage divide which meanders across the northern tier of counties in the State of Mississippi.

Topography

The topography in WRPA 3 consists of two distinctly different land forms separated by bluffs which parallel the Mississippi River. To the west of the bluffs lies the alluvial valley of the Mississippi River. The alluvial area (about 7.5 percent of the total WRPA) is flat with poor natural drainage. Most of the alluvial area is cleared and except for parks, fish and wildlife management areas, refuges, and preserves, the remaining woodlands are being depleted. Flow in unimproved streams is generally sluggish due to the flat stream slopes in the area. To the east of the bluffs there are gently rolling uplands dissected by numerous streams which flow through well-defined valleys. The upland area is about two-thirds cleared, with one-third of the area remaining in forests. Though stream slopes are steeper in the uplands, flow is sluggish due to obstructions on unimproved streams.

Elevations in the area vary from about 200 feet m.s.l. in the lowest areas in the alluvial valley to about 580 feet m.s.l. in the higher areas of the uplands.

The numerous stream basins in WRPA 3 were grouped into five planning basins: the West Kentucky-Cairo Basin, the Obion Basin, the Forked Deer Basin, the Hatchie Basin, and the Chickasaw Basin. These basins are shown on figure 8.

The West Kentucky-Cairo Basin is made up of the city of Cairo, Illinois, drainage area, and other minor drainage basins, all combined to total 32 square miles in the southern tip of Illinois; and the drainage basins of Mayfield and Obion Creeks, and Bayou Du Chien in west Kentucky. This planning basin has a total drainage area of 1,020 square miles. The major portion of the area in Illinois is flat and within levees to prevent Mississippi River and Ohio River overflow.

Each of the major streams in west Kentucky begins in steep hilly terrain and flows through narrow, well-defined flood plains into a small alluvial plain just before entering the Mississippi River.

The Obion Basin has a total area of about 2,400 square miles. The major streams are the Obion River and its principal tributaries, Running Reelfoot Bayou, and the North, Middle, South, and Rutherford Forks of the Obion River. An outstanding topographical feature of the area is the 13,000-acre Reelfoot Lake which was formed by the New Madrid earthquakes in 1811-1812. Generally, the streams originate along the Mississippi River-Tennessee River Divide and flow in a westerly direction through floodplains which vary in width from 1 to 3 miles to enter the alluvial valley. The alluvial valley has an average width of about 20 miles in this basin and is a significant part of the total area.

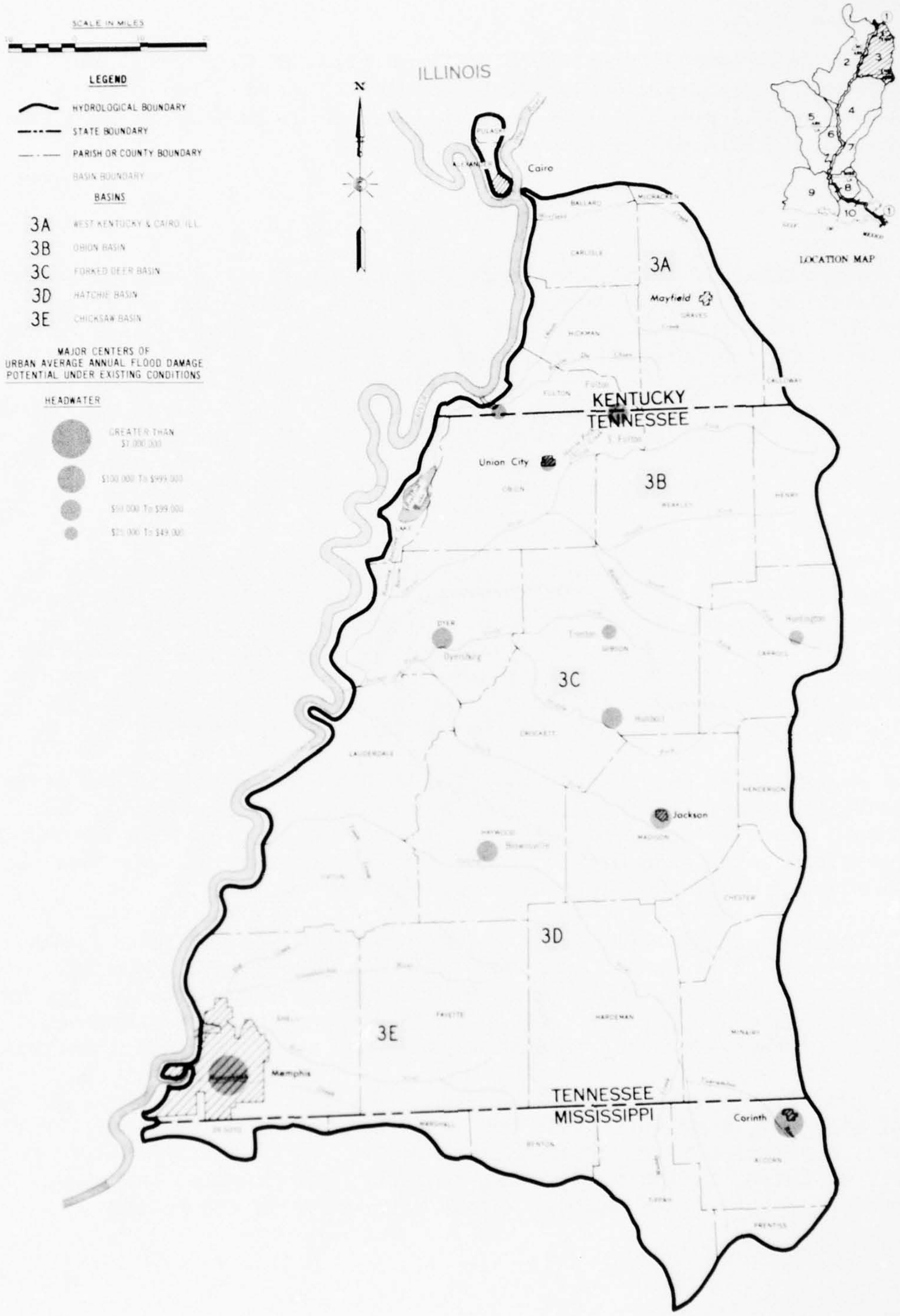
The Forked Deer Basin has a drainage area of about 2,100 square miles. Its principal tributary streams are the North, Middle, and South Forks of the Forked Deer River and the North Fork Drainage Canal. The streams originate near the east border of WRPA 3 and generally flow in a westerly direction through narrow floodplains bordered by gently rolling hills until reaching the alluvial valley where they join to form the main stem of the Forked Deer River. The alluvial valley contributes only a small part of this basin's total area, which may be characterized as generally hilly.

The Hatchie Basin consists of the Hatchie River Basin and the area tributary to the Mississippi River below the Forked Deer Basin. The main streams are the Hatchie River and its principal tributaries, the Tuscumbia River and Muddy Creek. This planning basin is the largest in WRPA 3 with an area of about 2,900 square miles. The topography is predominantly hilly with a small portion consisting of floodplain lands and alluvial valley lands.

The Chickasaw Basin consists of the combined drainage areas of the Loosahatchie and Wolf Rivers, Nonconnah Creek, and Horn Lake Creek, a total of about 1,810 square miles. The streams flow in narrow floodplains through hill lands and generally flow across the area in a westerly direction. All of these streams flow through the Memphis, Tennessee, SMSA.

Climate

The climate of WRPA 3 may be classed as generally warm and humid. The area lies in the path of rain-producing low pressure systems that move northeastward from the western part of the Gulf of Mexico and the dry continental air masses that move west to east across the middle of the continent. These air masses, together with the position of the Atlantic high pressure systems, are the primary influence on this area's climate.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 3 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 8

The mean annual temperature of the area is about 60° F., and the frost-free growing season is about 7 months. Records indicate that the mean annual precipitation is about 50 inches, and the maximum year's recorded rainfall was 74 inches in 1957.

Economy

Approximately 1,258,000 people, about 20 percent of the population of the Lower Mississippi Region, reside in the area which comprises WRPA 3. Urban population in 1970 was 70 percent of the total WRPA population. Major population centers were the Tennessee cities of Memphis (SMSA 760,110), Jackson (39,996), Dyersburg (14,523), and Union City (11,925), and the Kentucky city of Mayfield (10,724). WRPA population is projected to increase to 2,569,000 by 2020 under the National Income objective and to 2,983,000 by 2020 under the Regional Development objective. By 2020, 88 percent of the population will be located in urban areas.

Significant economic activities in the area include agriculture, manufacturing, and service industries. The major manufacturing categories are food and kindred products, chemical and allied products, paper and allied products, and textile mill products. The 1968 manufacturing gross product was approximately $1.3 billion and is expected to increase to $10.6 billion under the National Income objective and $12.5 billion under the Regional Development objective by 2020.

Agricultural output accruing from WRPA 3 ranks third in the Lower Mississippi River Basin. Major crops include cotton, soybeans, corn, and hay. In 1968 agricultural gross product was $322 million with 2020 projections being $546 million under the National Income objective and $645 million under the Regional Development objective.

Land use in the planning area, a total of 6,818,000 acres, consists of cropland, 25 percent; pasture, 5 percent; forests and woodlands, 34 percent; urban and built-up lands, 5 percent; water areas, 1 percent; and other lands, 6 percent. Urban lands are projected to increase 56 percent by the year 2020, as forest lands and other lands will decrease.

Land transportation is served by three interstate highways, 10 Federal highways, many more State and local highways and seven major railways. Waterborne transportation is moved on the Mississippi River past ports at Cairo, Illinois, Hickman, Kentucky, and Memphis, Tennessee. Memphis has the second busiest inland river port in the Nation.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Floods in WRPA 3 are generally caused by rainstorms which last several days and move northeastward across the area. These storms occur most frequently from January to May. Flooding in the area may be categorized into two distinct types of flooding which may occur singly or in combination as follows:

Backwater Flooding

Lands adjacent to the Mississippi River tributaries are subject to flooding due to high stages in these rivers as a result of high stages in the Mississippi River. Additionally, this type of flooding is aggravated by flow from the Mississippi River which backs into the tributary basin, increasing flood volumes. This Mississippi River flooding is primarily the result of runoff originating outside the planning area.

Headwater Flooding

Lands along various drainage arteries are subject to flooding due to high stages which are generated by runoff originating within the watershed tributary to those arteries.

Flooding along the South Fork, Obion River, May 1967.

Major Historical Floods

General flooding throughout WRPA 3 occurred in 1927, 1937, 1945, 1950, 1957, and 1973. A description of these significant floods follows.1/

1927 Flood

Rainfall throughout this area was unusually heavy from December 1926 to April 1927. There were three flood waves, occurring in January, February, and April and increasing in magnitude each time. The major storm of the flood occurred from 12-16 April and produced about 6 inches of rainfall over the area. The 18-day rainfall from 5-27 April averaged about 11 inches over the area.

In WRPA 3, approximately 450,000 acres were inundated, producing widespread damages throughout the area. Farms, homes, roads, and railroads were flooded and hundreds of people were forced to flee their homes until the waters subsided.

Tent camp near Hickman, Kentucky, for refugees during 1927 flood.

1/ Damage figures shown are dollar damages for each flood described only, and are not corrected to 1970 dollars.

1937 Flood

A period of almost continuous precipitation from the latter part of December 1936 through 16 January 1937, which was climaxed with a 9-day storm of high intensity, produced the January-March 1937 flood. Precipitation for the month of January averaged about 19 inches, while the 9-day final storm produced about 14 inches.

The flood inundated 343,000 acres of land and produced more than $1.2 million in flood damages from both headwater and backwater flooding.

1945 Flood

A series of heavy rains occuring from the middle of February to the first part of March 1945 over most of the Ohio River Basin and aided by snow melt in the northern areas produced backwater flooding in the tributary streams. Total damages were about $1.7 million in WRPA 3.

1950 Flood

Rainfall intensities which had been exceeded only by the 1937 rainfall fell over most of the area during early 1950. In the floods that followed, first from 10 January to 5 March and next during mid-May, there were approximately 619,000 acres flooded from backwater of the Mississippi River and headwater from the tributary streams. Total damages were about $1.7 million in WRPA 3.

1957 Flood

Serious flooding in WRPA 3 occurred both in April and in November 1957, flooding a total of 866,000 acres from both storms. In both cases, flooding was produced by a combination of Mississippi River backwater and headwater from tributary streams.

The floods described above are recorded as the more significant hydrologic events due to their widespread flooding which, in every case, was heavily influenced by Mississippi River backwater. There have been, however, numerous floods which have occurred annually on the smaller rivers and tributary streams of WRPA 3. These floods, though often confined to a single basin within the area, frequently have produced devastation to crops and farmlands in their paths, making tributary flooding a formidable problem throughout the lowlands of WRPA 3.

1973 Flood

Starting late in March 1973 and continuing through most of May, large areas of WRPA 3 were subjected to severe flooding along the Mississippi River and its tributary streams in the area. Small towns and farms in extreme West Tennessee were flooded and had to be evacuated as backwater spread over the low-lying portions, entering along tributary stream channels. In addition to the backwater flooding, private levees lying inside the main stem levees broke and allowed the headwaters of the Mississippi to flood thousands of acres, forcing the

evacuation of residents and destroying farmland, homes and businesses in these "protected" areas.

In mid-April as the Mississippi River had begun a slow fall, torrential rains struck, reversing the fall of the river and producing severe flash-flooding along several tributary streams in the area. These flash floods alone caused millions of dollars additional damages.

Statistically, the 1973 flood on the main stem fell between a 10 to 25-year frequency flood in the area bordering WRPA 3, with stages as much as eight feet lower than the 1937 record flood and 12 feet below project flood heights. Despite the fact that actual flood potential is far greater than the flooding experienced in 1973, WRPA 3 suffered extensive damages totalling an estimated $26.2 million over 162,600 acres of flooded area.

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed improvements which reduce damages from both headwater flooding of tributary streams and Mississippi River backwater flooding. These improvements are summarized below and in tables 17 and 18. Detailed information on the improvements is contained in the Inventory of Facilities Appendix.

Flood reduction on tributary streams consists of dams, channel enlargement, and clean-out operations in the Obion-Forked Deer Basins and on the Wolf River in the Chickasaw Basin. For Mississippi River main stem flooding, levees have been constructed to protect much of the area where no natural bluff line exists near the river.

Flooding in Cairo, Illinois, is controlled by flood walls and levees along the Ohio and Mississippi Rivers, while interior drainage is controlled by pumping stations.

At Memphis, Tennessee, flooding from the Mississippi River is prevented by a system of floodwalls and pumping stations.

Ensley Pumping Station and Mississippi River Levee provide flood protection for lowlands near Memphis, Tennessee.

Table 17 - Flood Control Storage, 1970, WRPA 3

Basin	Flood Control - Storage in 1,000 Acre-Feet: Major Reservoir	Small Reservoir	Totals
West Ky. & Cairo, Ill.	0	10.3	10.3
Obion	0	67.2	67.2
Forked Deer	0	11.0	11.0
Hatchie	0	90.5	90.5
Chickasaw	0	9.6	9.6
Total	0	188.6	188.6

Table 18 - Summary of Local Protection Projects, 1970, WRPA 3 1/

Basin	Levees and Floodwalls (Miles)	Channel Imp. (Miles)	Bank Stabiliz. (Miles)	Pumping Plants (No.)	(Total c.f.s.)
West Ky. & Cairo, Ill.	5.1	59.2	0	6	331
Obion	5.2	399.4	0	0	0
Forked Deer	0	109.4	0	1	26
Hatchie	0	403.9	0	0	0
Chickasaw	12.0	82.1	0	6	7,880
Total	22.3	1,054.0	0	13	8,237

1/ Consists of projects in both upstream watersheds and principal reaches.

Nonstructural Program

Flood Plain Information studies and reports and technical assistance are provided to urban areas for use in management of floodplians. The local governments may then utilize several approaches to floodplain management such as zoning ordinances, subdivision regulations, construction codes and flood proofing of existing structures. In WRPA 3 fourteen floodplain information reports have been completed or are underway.

Flood insurance studies conducted to provide a basis for rate determination and issuance of flood insurance are another source of floodplain information. Three such studies are completed or are underway in WRPA 3.

Land Treatment

Presently 2,617,000 acres of land located in WRPA 3 are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Data on acres with adequate treatment by basin are shown in table 19. Additional data on land use and land treatment are included in the Land Resources Appendix.

Table 19 - Land Treatment, WRPA 3

Basin	Lands Adequately Treated Acres (1,000's)
West Ky. & Cairo, Ill.	318
Obion	714
Forked Deer	560
Hatchie	690
Chickasaw	335
Total	2,617

Flood Forecasting

River and flood forecast service is provided by the National Weather Service office at Memphis, Tennessee. Forecast dissemination is largely provided via the news media through the use of the NOAA Wire Service, a teletypewriter network available to all bona fide mass news disseminators.

Emergency Operations

The Federal Government and State and local agencies have cooperated on numerous occasions when natural disasters have occurred in the area. Emergency operations performed in the past have included evacuation and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and clean-up and recovery operations.

Remaining Flood Problems

Most flood problems remaining in the planning area are in the areas where authorized works are not yet completed and/or where little or no protection is currently provided. Flooding patterns are similar in all Mississippi River tributary streams in WRPA 3. The upstream portions are subject to headwater flooding of short to medium duration, while the lower reaches near the Mississippi River are subject both to headwater flooding and extensive backwater flooding from the Mississippi River.

Homes flooded along South Fork, Forked Deer River near Halls, Tennessee, December 1972.

The major flood problems remaining in WRPA 3 are the results of inundation from headwater flooding on tributary streams to the Mississippi River and from backwater flooding from the Mississippi River. When currently authorized projects on the tributary streams are completed, much of the remaining flood damages will be prevented; however, Mississippi River flooding will continue to present a threat to those areas it affects with either headwater or backwater floods.

Due to their large sizes and greater number of streams, the Obion and Forked Deer Basins contain more of the rural damages than other basins in WRPA 3. Nonconnah Creek, a relatively small tributary stream in the Chickasaw Basin, which flows through the city of Memphis, creates more urban damages than all other streams in the WRPA combined with a present average annual damage rate of approximately $6 million.

Table 20 summarizes the area subject to flooding and average annual damages in principal reach areas by standard project floods and the Design Floods for the Mississippi River under existing development conditions.

Table 20 - Remaining Flood Problems (1970), Existing Conditions, WRPA 3

	Area Subject to Floods (1,000 Acres)		Average Annual Damages Due to Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
Basin	Principal Streams	Upstream Watersheds	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total	Agri.	Urban & Built-Up	Other	Total
West Ky. & Cairo, Ill.														
Headwater Flood	291	118	717	28	98	843	388	-	137	525	1,105	28	235	1,368
Backwater	24	-	62	-	6	68	-	-	-	-	62	-	6	68
Obion														
Headwater Flood	403	171	1,856	189	253	2,298	944	131	360	1,485	2,850	320	613	3,783
Backwater Flood	139	-	16	-	10	26	-	-	-	-	16	-	10	26
Forked Deer														
Headwater Flood	224	166	1,360	597	137	2,094	1,470	241	628	2,339	2,830	838	765	4,433
Backwater Flood	81	-	17	-	7	24	-	-	-	-	17	-	7	24
Hatchie														
Headwater Flood	163	224	266	284	44	594	1,734	229	416	2,379	2,000	513	460	2,973
Backwater Flood	14	-	7	-	3	10	-	-	-	-	7	-	3	10
Chickasaw														
Headwater Flood	92	149	411	5,875	20	6,306	858	661	235	1,754	1,269	6,536	255	8,060
Backwater Flood	16	-	204	95	14	313	-	-	-	-	204	95	14	313
WRPA 3 Total														
Headwater Flood	1,173	828	4,610	6,973	552	12,135	5,444	1,262	1,776	8,482	10,054	8,235	2,328	20,617
Backwater Flood	274	-	306	95	40	441	-	-	-	-	306	95	40	441
TOTAL						12,576				8,482				21,058

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are alternative levels of economic development; the National Income objective is based on the economic activity indicated by OBERS projections, while the Regional Development objective is based on a higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources. Details related to the alternative levels of economic development are contained in the Economics Appendix.

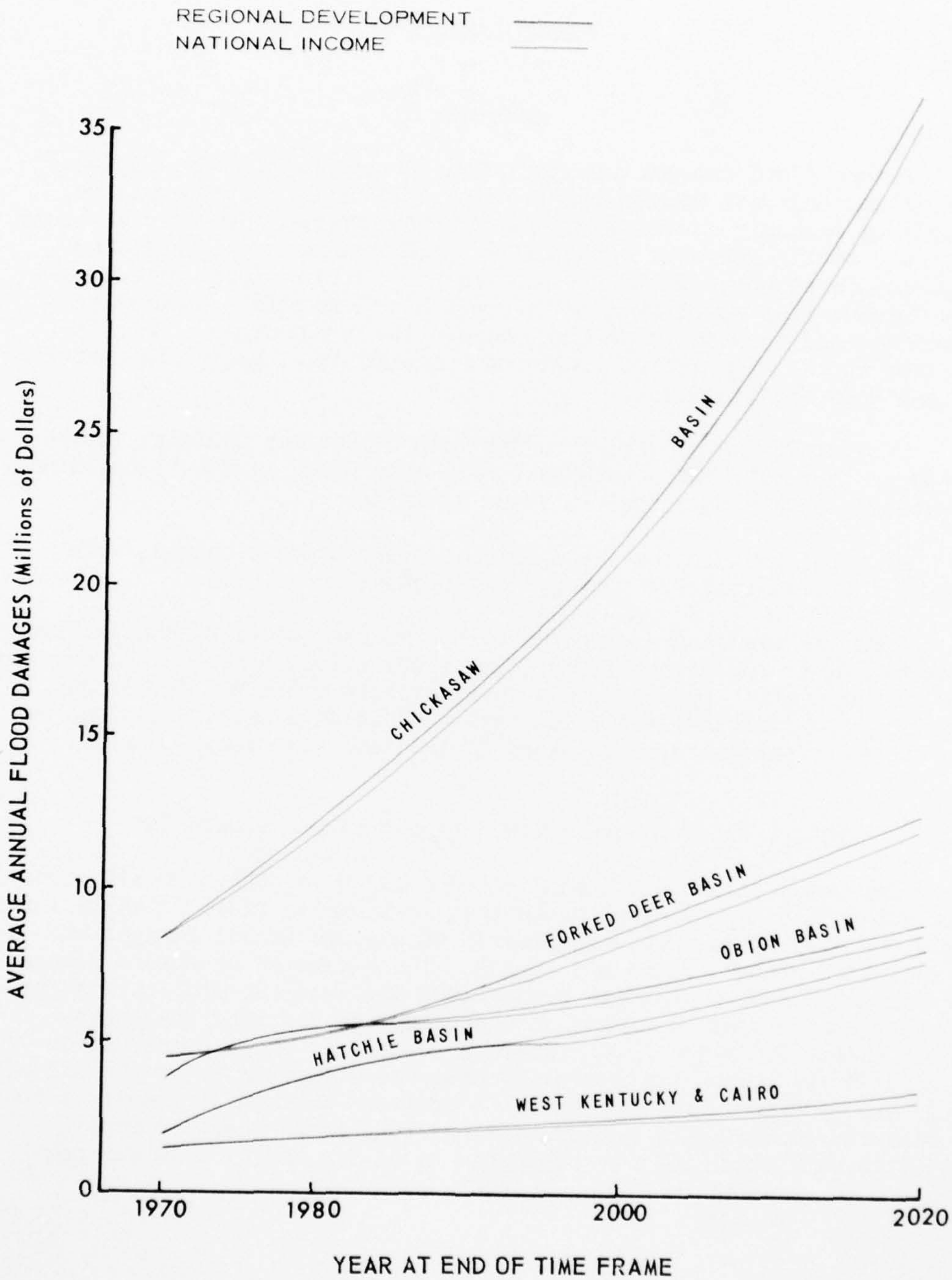
Projected land-use trends under both objectives indicate further urban and agricultural development will take place in the floodplains, increasing damage potential in those areas.

Crop patterns in the floodplains are expected to change, with reductions predicted for cotton and increases in soybeans.

Land-use trends are expected to be the same under both objectives; however, under the Regional Development objective, denser urban development is expected. Figures 9 and 10 illustrate projected levels and relative magnitudes of future damages. Additional details on land-use trend determinations are contained in the Land Resources Appendix.

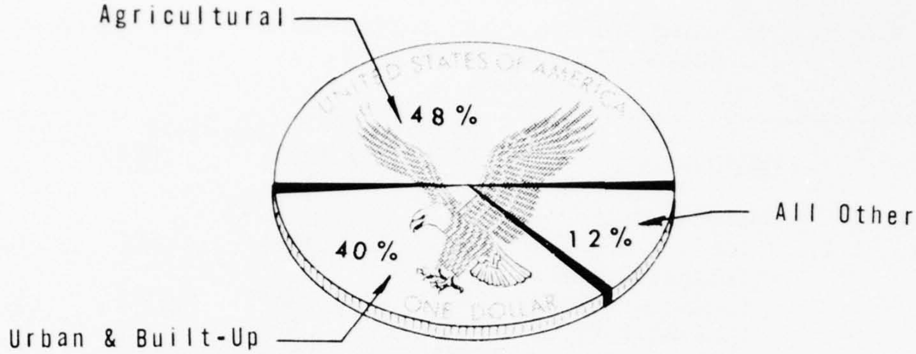
Future Flood Damages with National Income Growth Rate

The level of average annual flood damages in WRPA 3 on all streams including Mississippi River backwater, is shown in table 21 which lists base year (1970) and projected levels of average annual damages by principal drainage basins and causes. The estimates of future damage levels are based on economic projections and land-use projections for the National Income objective in the Economics and Land Resources Appendixes. Projects which require a relatively short construction period (a few years) which are now under construction or by the end of 1973 are assumed to be in place. On projects which will require a long, continuing construction period (some as long as 20 years or more), only the work which will be completed as of the end of 1973 was considered to be in place.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-3

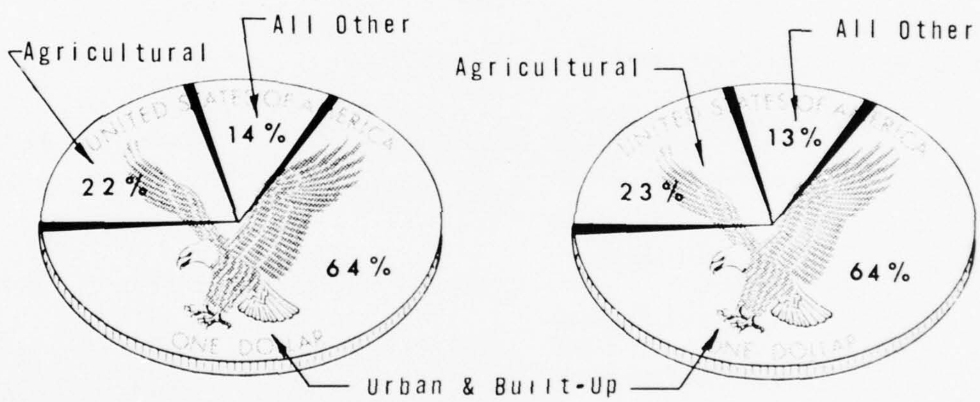
Figure 9



1970

NATIONAL INCOME

REGIONAL DEVELOPMENT



2020

DISTRIBUTION OF ANNUAL FLOOD DAMAGE

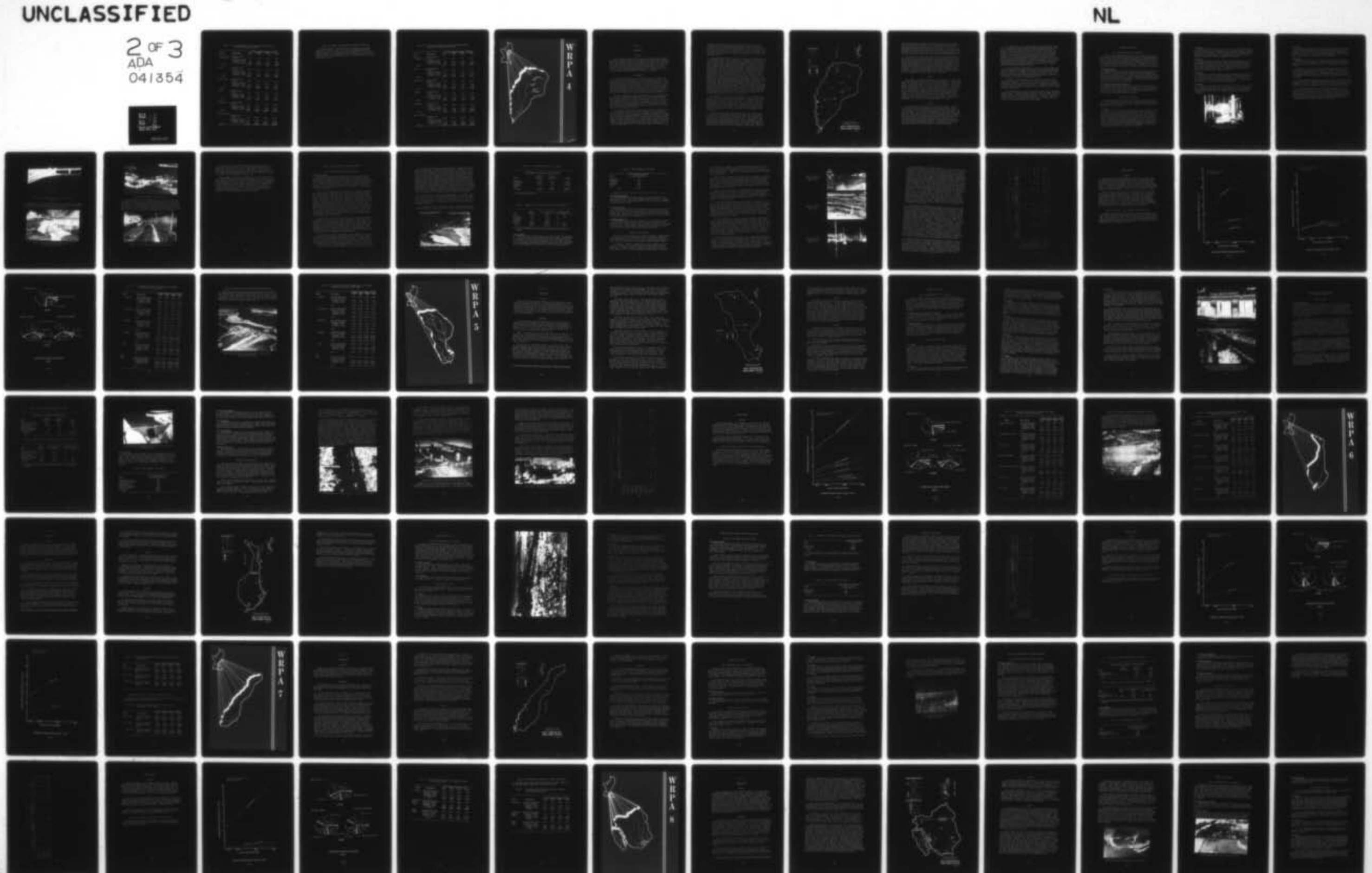
WRPA-3

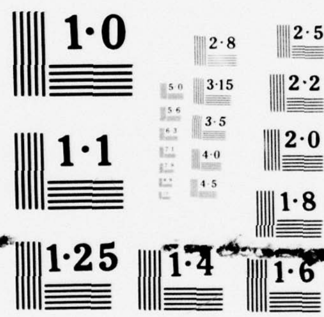
Figure 10

AD-A041 354 LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY COORDINA--ETC F/G 8/6
LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY. APPENDIX E. FLOOD--ETC(U)
1974

UNCLASSIFIED NL

2 OF 3
ADA
041354





NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

Table 21 - Existing and Projected Average Annual Flood Damages
National Income Growth, WRPA 3

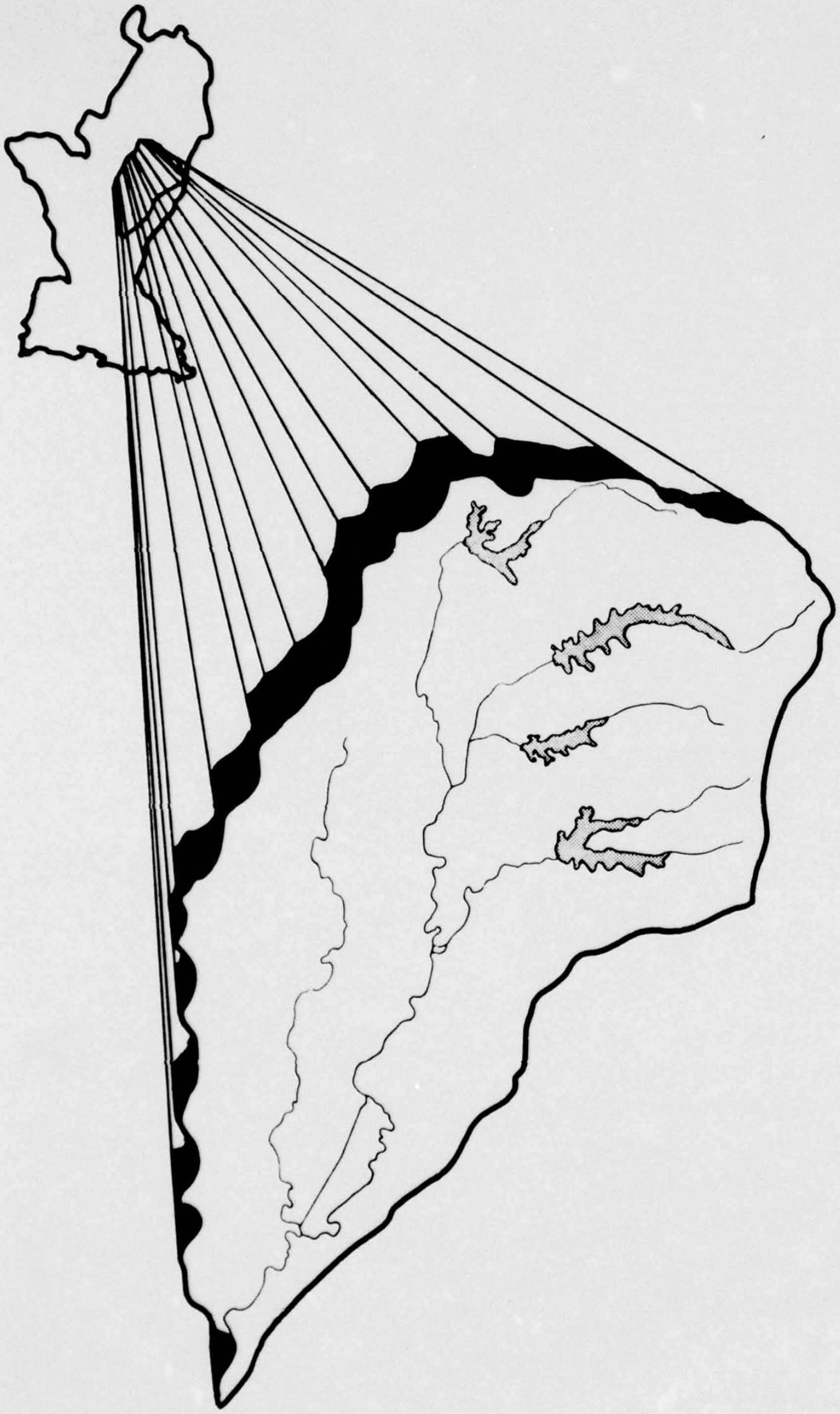
Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
West Ky. & Cairo, Ill.	Upstream Watersheds	525	640	867	1,163
	Principal Streams				
	Headwater Flood	843	1,100	1,342	1,820
	Backwater Flood	68	87	94	106
Total		1,436	1,827	2,303	3,089
Obion	Upstream Watersheds	1,485	1,831	2,571	3,606
	Principal Streams				
	Headwater Flood	2,298	3,578	3,914	4,924
	Backwater Flood	26	32	34	37
Total		3,809	5,441	6,519	8,567
Forked Deer	Upstream Watersheds	2,339	2,904	4,161	5,975
	Principal Streams				
	Headwater Flood	2,094	3,122	4,081	6,073
	Backwater Flood	24	35	37	41
Total		4,457	6,061	8,279	12,089
Hatchie	Upstream Watersheds	2,379	2,906	3,959	5,349
	Principal Streams				
	Headwater Flood	594	898	1,383	2,269
	Backwater Flood	10	16	18	24
Total		2,983	3,820	5,360	7,642
Chickasaw	Upstream Watersheds	1,754	2,228	3,404	5,231
	Principal Streams				
	Headwater Flood	6,306	9,242	16,639	28,815
	Backwater Flood	313	462	830	1,470
Total		8,373	11,932	20,873	35,516
WRPA 3 TOTALS					
	Upstream Watersheds	8,482	10,509	14,962	21,324
	Principal Streams				
	Headwater Flood	12,135	17,940	27,359	43,901
	Backwater Flood	441	632	1,013	1,678
Total		21,058	29,081	43,334	66,903

Future Flood Damages with Regional Development Growth Rate

Estimated future flood damages under the Regional Development objective are listed in table 22. Future flood damages under this objective will be of the same type as those estimated for the National Income objective. The magnitudes of rural damages are the same for both objectives, while urban damages show an increase under the Regional Development objective.

Table 22 - Existing and Projected Average Annual Flood Damages
Regional Development Growth, WRPA 3

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
West Ky. & Cairo, Ill.	Upstream Watersheds	525	641	897	1,205
	Principal Streams				
	Headwater Flood	843	1,104	1,360	1,879
	Backwater Flood	68	87	94	106
Total		1,436	1,832	2,351	3,190
Obion	Upstream Watersheds	1,485	1,833	2,652	3,723
	Principal Streams				
	Headwater Flood	2,298	3,542	4,075	4,993
	Backwater Flood	26	32	34	37
Total		3,809	5,407	6,761	8,753
Forked Deer	Upstream Watersheds	2,339	2,908	4,286	6,157
	Principal Streams				
	Headwater Flood	2,094	3,122	4,217	6,290
	Backwater Flood	24	35	37	41
Total		4,457	6,065	8,540	12,488
Hatchie	Upstream Watersheds	2,379	2,908	4,094	5,539
	Principal Streams				
	Headwater Flood	594	909	1,399	2,389
	Backwater Flood	10	16	18	24
Total		2,983	3,833	5,511	7,952
Chickasaw	Upstream Watersheds	1,754	2,232	3,489	5,363
	Principal Streams				
	Headwater Flood	6,306	9,280	16,897	29,519
	Backwater Flood	313	466	842	1,491
Total		8,373	11,978	21,228	36,373
WRPA 3 TOTALS					
	Upstream Watersheds	8,480	10,522	15,418	21,987
	Principal Streams				
	Headwater Flood	12,135	17,957	27,948	45,070
	Backwater Flood	441	636	1,025	1,699
Total		21,058	29,115	44,391	68,756



W R P A 4

W R P A 4

DESCRIPTION

General

WRPA 4 covers an area of 13,355 square miles and occupies approximately the northwest quarter of the State of Mississippi (see figure 11). The western boundary of the area is formed by the east bank Mississippi River levee to the vicinity of Vicksburg, Mississippi, where the boundary becomes the east top bank of the Mississippi River. The area is bordered on the north by the divides of the Wolf and Hatchie River Basins. The eastern and southern boundaries are formed by the divides of the Tombigbee and Big Black River Basins, respectively.

Topography

The physical characteristics of the WRPA divide it into two distinct areas, usually referred to as the delta and hill sections. The delta section lies in the alluvial valley of the Mississippi River and occupies the western half of the WRPA. The terrain of this area is very flat, with an average slope from north to south of 0.5 foot per mile. The hill section lies in the eastern half of the WRPA and has topography varying from gently rolling to rugged hills. Elevations in this section range from 100 feet m.s.l. near Yazoo City, Mississippi, to over 600 feet on the highest hills in the northeast corner of the WRPA.

The area in WRPA 4 consists almost entirely of the drainage basin of the Yazoo-Tallahatchie-Coldwater Rivers system and its tributaries, the remainder consisting of small areas draining directly into the Mississippi River in the vicinity of Vicksburg, Mississippi. The principal drainage areas as discussed in this summary are the Coldwater River Basin, the Tallahatchie River Basin, the Yalobusha River Basin, the Big Sunflower River-Steele Bayou Basin, and the Yazoo River Basin. These areas are shown on figure 11.

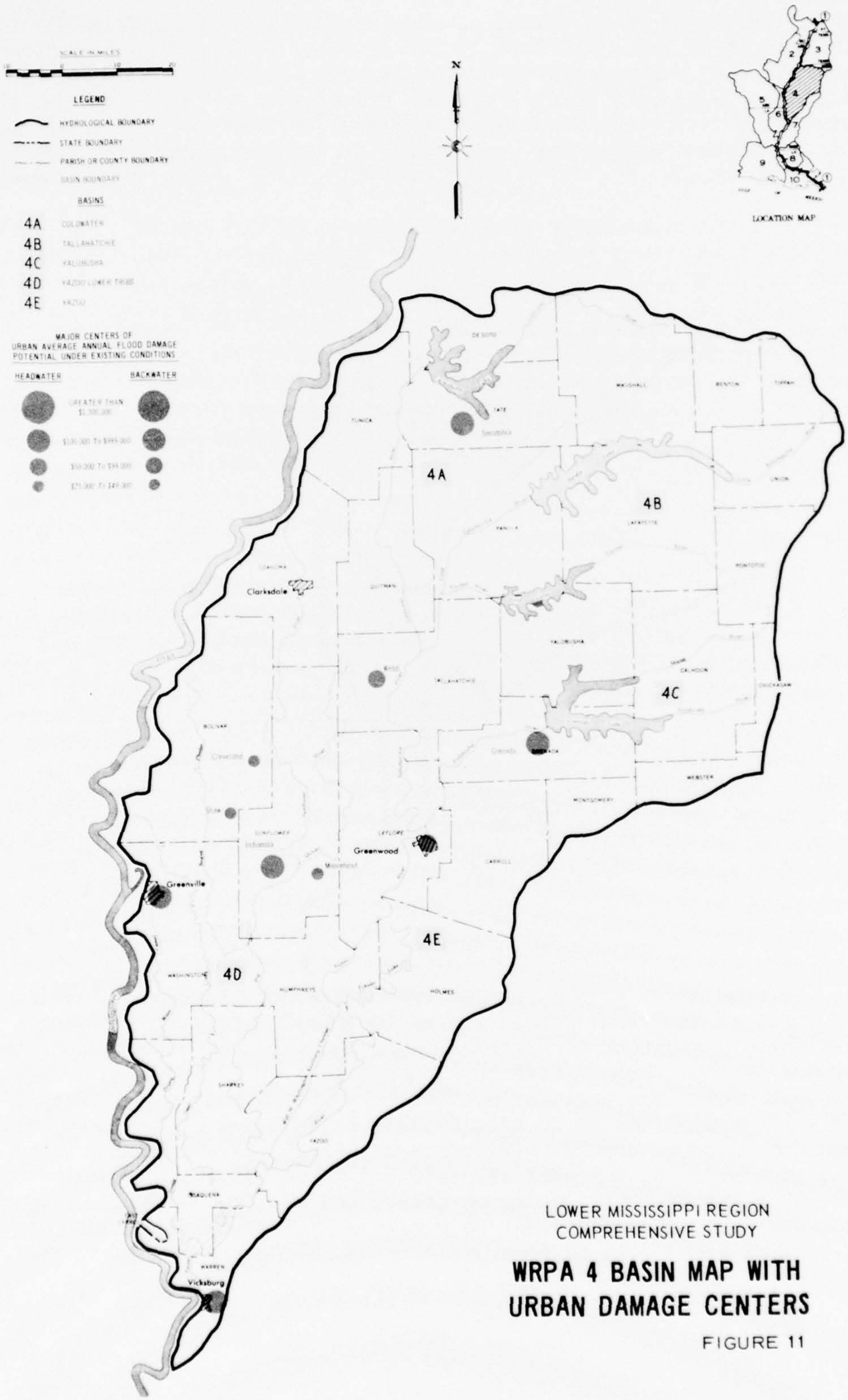
The Coldwater River Basin is the drainage area of Coldwater River and its tributaries and covers an area of about 1,980 square miles. The Coldwater River rises in the hills of Marshall County, Mississippi, and is joined by Hickahala and Pigeon Roost Creeks and smaller streams before flowing into Arkabutla Lake. Leaving the lake, Coldwater River enters the delta section where it is joined by the flows from the Lake Cormorant area, Arkabutla Canal, and other smaller streams. In the vicinity of Crenshaw, Mississippi, the flow of the Coldwater River is diverted through Pompey Ditch. The remaining channel of Coldwater River

collects discharges of Whiteoak Bayou and other northwestern delta streams before rejoining Pompey Ditch north of Marks, Mississippi. Here the stream is joined by David and Burrell Bayous. In the vicinity of Lambert, Mississippi, the Coldwater River is met by the channel of Old Little Tallahatchie River, which now carries only the flows of Bobo Bayou and smaller streams. At this point, Coldwater River becomes Tallahatchie River.

The Tallahatchie River Basin as discussed here is the drainage area of Tallahatchie River and its tributaries, excluding the drainage basin of the Coldwater River. The drainage area encompasses 3,420 square miles, of which 2,650 square miles lie in the hill section. The remaining 770 square miles are drained by tributaries in the delta section. The principal hill tributaries are the Little Tallahatchie and Yocona Rivers, which originate in Union and Pontotoc Counties, Mississippi, respectively. The Little Tallahatchie River is joined by Tippah River and smaller tributaries before discharging into Sardis Lake. Below the lake the Little Tallahatchie River is routed through the Panola-Quitman Floodway, which also collects flows from Yocona River before entering the Tallahatchie River west of Charleston, Mississippi. The Yocona River, joined by Otoucalofa Creek and smaller tributaries, enters Enid Lake in northern Yalobusha County, Mississippi. Downstream of the lake, Yocona River enters the Panola-Quitman Floodway near Crowder, Mississippi. The principal delta tributaries of Tallahatchie River are Cassidy, Opossum, and Hurricane Bayous. Tillatoba Creek, a hill tributary, enters Tallahatchie River at the junction with the Panola-Quitman Floodway. The Tallahatchie River main stem begins at the confluence of the Coldwater River with the channels of Old Little Tallahatchie and Old Yocona Rivers and terminates at Greenwood, Mississippi, where it and the Yalobusha unite to form the Yazoo River.

The Yalobusha River Basin is the drainage area of Yalobusha River and its tributaries. The basin covers about 2,050 square miles, most of which lies in the hill section of the WRPA. Yalobusha River rises in Chickasaw County, Mississippi, and flows in a westerly direction. Near Grenada, Mississippi, the Yalobusha and Skuna Rivers merge with smaller streams to form Grenada Lake. Downstream of the lake, Teoc and Potococowa Creeks, Ascalmore Creek-Tippo Bayou and Bogue Batupan enter the Yalobusha River before it combines with Tallahatchie River at Greenwood.

The Big Sunflower River-Steele Bayou Basin covers 4,093 square miles and lies in the delta section of the WRPA. The Big Sunflower River rises in Coahoma County, Mississippi, and flows southerly for over 200 miles before entering the Yazoo River. The principal tributaries of the Big Sunflower River are the Quiver, Hushpuckena, and Little Sunflower Rivers and Bogue Phalia. The Steele Bayou Basin extends from the northwestern end of Washington County, Mississippi, to the Yazoo River, 10 miles north of Vicksburg, Mississippi. The main



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 4 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 11

stem of Steele Bayou is formed at Swan Lake by the junction of flows from Main Canal and Black Bayou. The drainage basins of Big Sunflower River and Steele Bayou are separated by Deer Creek. The Will M. Whittington Auxiliary Channel crosses the southeast section of the Big Sunflower River-Steele Bayou Basin and diverts a major portion of flood flow out of the Yazoo River near Silver City, Mississippi, and passes it down to reenter the Yazoo River near the mouth of Big Sunflower River.

The Yazoo River Basin as discussed here is the drainage basin of main stem Yazoo River from Greenwood to Vicksburg and does not include the drainage basins of upstream tributaries mentioned previously. The basin drains approximately 1,812 square miles, which is almost equally divided between delta and hill areas. Yazoo River is formed at Greenwood by the confluence of the Tallahatchie and Yalobusha Rivers. From Greenwood the river flows 169 miles to meet the Mississippi River at Vicksburg. Tributaries not mentioned in preceding paragraphs include Tchula Lake, Alligator-Catfish Bayou, Bear, Pelucia, Big Sand, Abiaca, Chicopa, Fannegusha, and Black Creeks, and Rocky Bayou.

Climate

The climate in the WRPA is generally considered mild. Summers are long, hot, and humid, and winters are short and moderate. During winter months the prevailing wind is from the north or northwest. During other seasons, prevailing winds are from the south and southwest. The normal annual temperature is 64° F. Observed extremes in the area range from 115° F. to minus 16° F. The normal annual precipitation is 52 inches. The heaviest rainfall normally occurs during the months of December to April, while the least amount normally occurs during September and October. Severe rainfall, producing locally intense runoff, however, can occur at any time of the year. The normal length of frost-free growing period for the WRPA is a little over 7 months. Snowfall occurs about once a year and the average annual amount is 2 inches.

Economy

The population of the WRPA in 1970 was about 638,000 - close to 10 percent of the total population of the Lower Mississippi Region. Sixty-three percent of the population in the WRPA was rural and 37 percent was urban. Seven cities have populations of 10,000 or more. The principal cities are Greenville, Vicksburg, Greenwood, and Clarksdale, with 1970 populations of 39,648, 25,478, 22,400, and 21,673 respectively. There are 32 towns having populations between 2,500 and 10,000. The total population of the WRPA is projected to be 828,000 by the year 2020 under the National Income objective and 941,000 by the same year under the Regional Development objective. Projections indicate that the general trend will be toward a more urbanized population.

The economy of the area is based primarily on agricultural activities. The manufacturing, forestry, fishery, and numerous other industries, however, also make considerable contribution to the area's economy. Eighty-two percent of the area is in crop and pasture lands and forests. The major crops are cotton, soybeans, rice, and small grains. Production of beef cattle and hogs are the major livestock enterprises. In 1970 agricultural production was valued at $499.8 million. Crop production accounted for almost 90 percent of this total, the remaining being attributed to livestock production. Total agricultural production is projected to increase to almost $899 million by 2020 under the National Income objective and to almost $977 million under the Regional Development objective.

The major manufacturing industries in the area are the lumber and furniture, textile mill, apparel and other textile and machinery industries. In 1968 the production of manufacturing industries was valued at $330.7 million. This value is projected to increase to over $3.5 billion by 2020 under the National Income objective and to almost $4.2 billion under the Regional Development objective.

The number of people employed in the WRPA in 1968 was 231,000 having total earnings of $973.7 million. The agricultural, forestry, and fishery industries accounted for 27 percent of the total earnings, and manufacturing accounted for 21 percent. Government, wholesale and retail trade, and services accounted for 16, 14, and 10 percent of total earnings, respectively.

Land transportation in the area is made possible by two interstate highways and five Federal highways, numerous State and county roads, and eight railways. Vicksburg and Greenville, Mississippi, offer port facilities to traffic on the Mississippi River. Vicksburg is designated a Port of Entry. Barge ports are located along the Yazoo River at Yazoo City, Greenwood, and Belzoni, Mississippi.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in the WRPA generally occurs in the winter and spring months and may result from the runoff of a single storm having duration of a few days or a series of storms extending over a period of several months. The occurrence and intensity of flooding are affected by seasonal upstream conditions influencing the Mississippi River as well as local storm conditions and drainage patterns. Flooding in the area can be classified as two distinct types - headwater and backwater flooding.

Headwater Flooding

Tributary streams are subject to overflow when storms of considerable duration or short but intense storms cause local and upstream drainage areas to produce excessive runoff. Headwater flooding along principal streams is caused by increased discharges from upstream watersheds and large amounts of local runoff. Flooding along upstream reaches is caused by excessive local runoff and may be increased where local drainage patterns are poorly developed.

Mississippi River Backwater Flooding

Alluvial lands in the southern part of the WRPA are subject to flooding from high stages in the Mississippi River. These high stages cause backwater flow to inundate local unprotected areas and also to "back up" tributary channels where it combines with channel flow to cause flooding in unprotected upstream areas.

Major Historical Floods

Generally widespread flooding in the WRPA occurred in 1927, 1932, 1937, 1948, 1958, 1961, 1969, and 1973. A brief discussion of the extent and intensity of the earlier floods follows with a more complete discussion of the 1973 flood.

1927 Flood

The flood of 1927 was the most disastrous in the recorded history of the Yazoo Basin. Rains fell for months over 31 states and two Canadian Provinces drained by the Mississippi River. Record stages caused the Mississippi River levees to crevasse in several places, allowing flood waters to spread over much of the area. Over 2 million acres of fertile alluvial land were inundated. Cities, towns, and farms were flooded, crops were destroyed and industries paralyzed. The flood resulted in an estimated $43 million damage and accounted for 60 deaths within the WRPA. Evacuation of thousands of persons from flooded areas prevented even greater loss of life.

1932 Flood

The 1932 flood was the result of a series of storms which occurred from 16 November 1931 to 21 February 1932. During this period, rainfall at Swan Lake, Mississippi, measured 51 inches, which is almost equal to the total for a normal year. It is estimated that 1,139,000 acres were inundated, resulting in damages amounting to $1,350,000.

1937 Flood

The flood of 1937 in WRPA 4 caused significant damage only in the Mississippi River backwater areas. However, this great Mississippi River flood was significant in WRPA 4 since it provided the first true test of the extensive levee and flood protection system built after 1927 along the Mississippi River. The system held, preventing what could have been disastrous flooding in WRPA 4.

1948 Flood

The flood of February 1948 was caused by unusually heavy rains in the Yazoo Basin. Over a 3-day period, amounts of rainfall varied from 8.2 inches at New Albany and Ripley, Mississippi, to 2.5 inches at Vicksburg, Mississippi. The flood overflowed an area of 726,000 acres and resulted in an estimated $4.6 million damages.

1961 Flood

Heavy rains throughout the basin caused the flood of April and May 1961. Saturated soil conditions, due to preceding rains, caused maximum runoff during and after the storm's occurrence. Along streams in the area over 667,000 acres were flooded, with damages amounting to $2,218,000.

Downtown Greenville, Mississippi, during 1927 flood.

1969 Flood

This flood resulted from a storm during the period 18-19 November. During this period rainfall varied from 7.8 inches at Greenville, Mississippi, to 2.1 inches at Rolling Fork, Mississippi. Rainfall over the basin averaged 4.7 inches. The flood inundated an area of 340,000 acres and resulted in an estimated $1,815,000 damages.

1973 Flood

The flood of 1973 will be recorded as one of the most devastating ever to occur in the Yazoo Basin. The flood dramatically showed the devastating effect that flooding can have on the people and economy of an area.

Beginning in the fall of 1972, the entire Mississippi Valley experienced heavy rainfall, often torrential in nature, over wide areas. The rains prevented harvest of a significant portion of the 1972 crop. The rainfall in WRPA 4 kept the soil saturated and began to fill the flood control reservoirs which set the stage for the flooding which was to follow.

As the rainfall continued into the winter months, an ominous pattern began to take shape in hydrograph readings of the Mississippi River. By December the river was assuming a typical pre-flood pattern somewhat ahead of the stage developments which preceded the great flood of 1927.

As the Mississippi River was still rising, torrential rains on March 15 and 16 occurred in WRPA 4. Spectacular totals of almost 10 inches for the two-day period were recorded at some stations. Sardis, Enid, and Grenada Reservoirs all flowed over their emergency spillways for the first time in history. Later, Arkabutla Reservoir flowed over its spillway as the result of other rain periods. Some roads were closed by high water, bridge washouts, or mud slides.

Grenada Dam, emergency spillway used for first time, March 1973.

Flash flooding from the torrential rains was a problem in a number of urban areas. Hardest hit were Vicksburg and Greenwood, Mississippi. Cleanup operations continued for weeks in some areas.

Water rushing into Eagle Lake after dam failure endangers bridge, 1973.

Agricultural flooding, Yazoo River, 1973.

As the swollen Yazoo River inundated large delta areas, the rains continued for several weeks, making it impossible for many farmers even in fields above the high water to prepare for planting. As the Mississippi River rose higher and higher, more and more of the backwater areas were flooded. An approximate 1,050-square-mile area north of Vicksburg was affected. Most of the damage in this area was agricultural, but many homes were flooded - particularly in outlying areas of Vicksburg.

Emergency levee raising, Greenwood, Mississippi, 1973.

The flood of 1973 had the second longest duration of any Mississippi River flood of record. This was particularly distressing to farmers who were unable to plant any crops or were forced to plant substitute crops with lower returns. Some families were forced out of their homes for months and many homes were severely damaged or destroyed as a result of the long duration of the flood.

Total damages in WRPA 4 were estimated to be $169.4 million with about $134.6 million (79 percent) being agricultural. Damages to urban areas amounted to about $15.8 million (9 percent of total). Damages to Federal property and roads, bridges, and railroads were high, amounting to $12.2 million (7 percent of total) and $4.2 million (3 percent of total), respectively. The remainder of the damage ($2.6 million) resulted from rerouting of traffic; evacuation, dislocation, and rehabilitation; and flood fighting. A total of 1,711,350 acres were flooded - 672,750 of which were flooded by backwater.

Existing Flood Damage Prevention Program

Structural Program

The Federal Government, in cooperation with local interests, has constructed flood control projects that prevent considerable damages from headwater flooding and to a lesser extent, Mississippi River backwater flooding. However, problems still exist in many areas as evidenced by the widespread flooding of 1973. A summary of protective measures provided by these projects is given in tables 23 and 24. Detailed information on existing structural measures is contained in the Inventory of Facilities Appendix.

Areas in the Coldwater River Basin receiving a degree of protection are located along Coldwater River, McKinney, David, Burrell, and Bobo Bayous and Arkabutla Canal, as well as in the Buck Island Bayou watershed and that part of the Yazoo River watershed[1/] lying in the Coldwater Basin. Flood control measures along Coldwater River include levees and channel improvement. The area in the vicinity of McKinney Bayou is benefited by a pumping plant and channel improvement. The David, Burrell, Bobo, and Buck Island Bayou areas, as well as lands adjacent to the Arkabutla Canal, are given a degree of protection by channel improvement. Flood control projects in these areas are directed toward reducing damages resulting from headwater flooding. Large reservoirs on the Coldwater, Little Tallahatchie, Yocona, and Yalobusha Rivers greatly reduce flood damages on these streams and contribute to flood reduction for some distance downstream. Smaller reservoirs in the Yazoo watershed aid in protecting local upstream areas.

In the Tallahatchie River Basin damages due to headwater flooding are reduced to a certain extent along Tallahatchie, Yocona, and Little Tallahatchie Rivers and Cassidy Bayou. In upstream areas, damages are reduced in the Hopson Bayou and Little Tallahatchie River watersheds and that part of the Yazoo River watershed lying in the Tallahatchie and Yocona Rivers and Cassidy and Hopson Bayous. Land adjacent to Little Tallahatchie River is benefited by levees and channel improvement. Upstream reservoirs help minimize flood damages in the Little Tallahatchie watersheds while also benefiting downstream reaches.

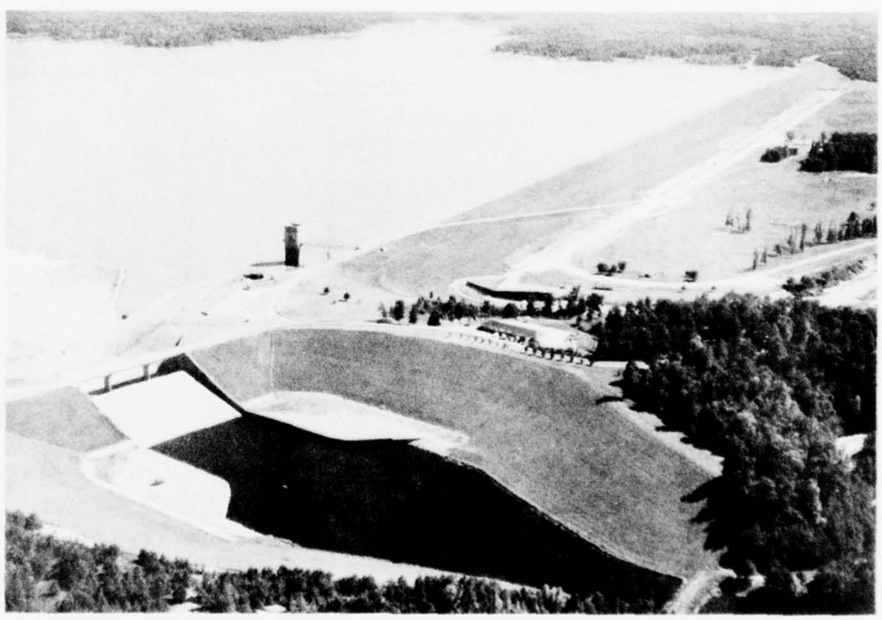
Areas offered a degree of protection in the Yalobusha River Basin are adjacent to Potococowa Creek, Yalobusha River, and in that section of the Yazoo River watershed lying within the basin. Channel improvements and upstream reservoirs offer some protection to all these areas.

1/ The Yazoo River watershed as discussed here is the hill section of the WRPA, except in the Tallahatchie River Basin. In this basin it is exclusive of the Little Tallahatchie River area above Sardis Lake.

In the Big Sunflower River-Steele Bayou Basin, channel improvement reduces damages due to headwater flooding along Big Sunflower, Little Sunflower, and Hushpuckena Rivers, Steele, Harris, Black, Mound, Jones, Porter's, Dawson, Ditchlow, Twin Lakes, Dowling, Gin, and Muddy Bayous, Deer and Mill Creeks, and Main Canal Riverside Drainage Ditch. In addition to these areas, damages are also reduced by channel improvement along the main stems and tributaries of Quiver River and Bogue Phalia. Along upstream reaches channel improvement benefits the watersheds of Beaver Dam, Harris, Home Cypress, Indian, and Moorhead Bayous, and the upper reaches of Bogue Phalia and Quiver River. A degree of protection from damages due to backwater flooding is provided by a system of levees, channel work, and drainage structures along the lower reaches of Yazoo River and the confluence of Big and Little Sunflower Rivers, Deer Creek, and Steele Bayou. However, with very high stages on the Mississippi River, as occurred in 1973, large areas are inundated by backwater.

In the Yazoo River Basin channel improvements offer partial protection from damages due to headwater flooding along the Yazoo River and Tchula Lake. In addition to channel work, levees also offer some protection to areas adjacent to Yazoo River. In that part of the upstream hill area known as the Yazoo watershed, reservoirs retain some of the potential floodwater.

In several areas in the WRPA local interests have further provided protection through drainage improvements and local protection measures.



Enid Dam and Reservoir, Yocona River, Mississippi.

Table 23 - Flood Control Storage, 1970, WRPA 4

	Flood Control - Storage in 1,000 Acre-Feet		
Basin	Major Reservoir	Small Reservoir 1/	Totals
Coldwater	493.8	25.2	519.0
Tallahatchie	2,064.3	85.5	2,149.8
Yalobusha	1,251.7	37.9	1,289.6
Sunflower	0	0	0
Yazoo	0	113.6	113.6
Total	3,809.8	262.2	4,072.0

1/ Existing and authorized.

Table 24 - Summary of Local Protection Projects, 1970, WRPA 4 1/

Basin	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Coldwater	40.0	444.1	1	250
Tallahatchie	8.4	728.3	0	-
Yalobusha	1.5	476.0	0	-
Sunflower	61.3	1,360.1	0	-
Yazoo	149.6	443.3	2	1,215
Total	260.8	3,451.8	3	1,465

1/ Consists of projects in both upstream watersheds and principal reaches.

Land Treatment

Presently almost 2 million acres of land in the WRPA are adequately treated to reduce erosion and sedimentation and to reduce surface runoff. This treatment results not only from local, State, and Federal group efforts, but also from individual landowner's efforts. Data on acreages receiving adequate treatment by basin are shown in table 25. Additional data on land treatment are included in the Land Resources Appendix.

Table 25 - Land Treatment, 1970, WRPA 4

Basin	Lands Adequately Treated Acres (1,000's)
Coldwater	334
Tallahatchie	473
Yalobusha	292
Sunflower	590
Yazoo	279
TOTAL	1,968

Nonstructural Program

Four Flood Plain Information reports have been completed or are underway in WRPA 4. These reports summarize the effects of the largest known floods in the area and delineate the areas that might be inundated by probable future floods.

Flood Forecasting

River and flood forecasts are provided by the National Oceanic and Atmospheric Administration's Weather Service office in Jackson, Mississippi. Much of the forecast dissemination is provided by the news media through NOAA's Weather Wire Service, a teletypewriter network available to all bona fide mass news disseminators.

Emergency Operations

The Federal, State, and local agencies have cooperated on numerous occasions where natural disasters such as floods and tornadoes have struck an area. Emergency operations performed in the past have included flood fighting to reduce damages, evacuation and assistance to reduce loss of life in threatened areas, and recovery operations.

Remaining Flood Problems

While the existing program does prevent considerable damage throughout the WRPA, many areas still remain subject to damages in extreme flood situations such as occurred in 1973. Potential damages remaining in the WRPA are the result of both headwater and backwater flooding.

An estimate of monetary damage alone can not completely show the effect of flooding. Also to be recognized are the suffering and inconvenience of families forced to flee from flooded areas, the hardships imposed by the closing of frequently traveled roads, the massive

effort required in attempts to save unprotected or partially protected areas, and the general disrupting effect on the economy of a region. Also to be considered is the danger to people living in floodprone areas and to flood workers. In WRPA 4, several deaths were directly attributed to the 1973 flood.

While overbank flooding causes substantial flood damages in certain urban areas, this is by no means the only source of flooding problems in urban areas. Inadequate storm sewers and drainage outlets can cause severe flooding problems while adjacent streams are still within banks. Data on this type of problem was not sufficient to estimate average annual damages. Therefore, urban average annual damages for WRPA 4 do not include this type of flooding.

An area of over 2 million acres along principal reaches and 1.9 million acres in upstream watersheds remains subject to headwater flooding with existing projects in place. Backwater flooding still threatens 725,000 acres with existing projects in place. Urban and built-up areas subject to flooding and having average annual damages of $25,000 or greater are shown in figure 11.

In the Coldwater River Basin, lands susceptible to headwater flooding lie in areas drained by Whiteoak, Bobo, David, and Burrell Bayous, and in the Lake Cormorant areas as well as in small areas along Coldwater River below Pompey Ditch. Local areas in upstream watersheds suffer damages from floodwaters caused by excessive rainfall as well as stream overflow. Most of the damages is to crop and pasture lands and to other improvements such as highway and railroad transportation facilities. The town of Senatobia, Mississippi, occasionally sustains damage due to flooding along Senatobia Creek.

In the Tallahatchie River Basin headwater flooding would cause damages to crop and pasture lands along the delta streams of Hurricane, Cassidy, and Opossum Bayous, Tallahatchie River, and the lower reaches of Tillatoba Creek. Some damages are caused by flooding along the Little Tallahatchie and Yocona Rivers. The town of Webb, Mississippi, is damaged when Cassidy Bayou overflows. Considerable headwater damages are experienced in the upstream watersheds, most of which are sustained by agricultural lands. Damages are not restricted to specific areas because the flooding depends to a great extent on local drainage patterns as well as channel capacities.

In the Yalobusha River Basin the city of Grenada, Mississippi, is subject to overbank flooding of Batupan Bogue. Significant agricultural damages can occur along Tippo Bayou, Ascalmore Creek, and the lower reaches of Yalobusha River. Some damages are sustained along the lower reaches of two hill tributaries Potococowa and Teoc Creeks. In upstream watersheds damages are relatively low as compared to upstream watersheds in other basins, these damages being primarily agricultural.

Suburban flooding
Greenwood, Miss.,
March 1973.

Suburban flooding
Greenwood, Miss.,
March 1973.

Suburban flooding
Vicksburg, Miss.,
March 1973.

The Big Sunflower River-Steele Bayou Basin is subject to headwater and backwater flooding. Because the area is relatively flat, low stream gradients preclude adequate drainage during periods of excess runoff. In addition, channel capacities are not adequate during extreme flows. As a result, the possibility of fairly widespread headwater flooding as occurred in 1973 is high. Damages to agricultural lands, transportation facilities, and other improvements are concentrated along Big Sunflower River below Indianola, Mississippi, Steel Bayou, and Bogue Phalia. Considerable damages of the same type are experienced during severe floods along the upper reaches of Big Sunflower River, Quiver, and Hushpuckena Rivers, and Deer Creek. Major floods would inflict damages on the urban areas of Greenville, Indianola, Shaw, Drew, Hollandale, and Leland, Mississippi, and the built-up areas of Moorhead, Ruleville, and Mound Bayou, Mississippi. Of the total damages to upstream watersheds in the WRPA, almost half occur in this basin. Backwater flooding still threatens large areas in the southern part of the basin. Sections in southern half of the area lying between Yazoo River and the Will M. Whittington Auxiliary Channel known as the Carter Area and areas along the lower reaches of Big Sunflower River and Steele Bayou are the principal areas subject to this type of flooding. Damages in these areas are primarily to pasture and crop lands. However, urban and built-up areas also suffer damages in major floods.

In the Yazoo River Basin extreme headwater stages would cause damages to agricultural areas along the main stem and tributaries of Yazoo River from Greenwood to the vicinity of Yazoo City, Mississippi. Damages in these areas would also be experienced by other improvements such as roads and bridges. Tributaries along which damages could occur include Pelucia, Abiaca, Big Sand, Chicopa, and Bear Creeks. The occurrence of serious headwater flooding of the Yazoo River would cause damages in the vicinity of Greenwood, Mississippi. Flooding along Black Creek, a hill tributary, would result in damages to Lexington, Mississippi. Low-lying areas below Yazoo City, Mississippi, are subject to backwater flooding from the Mississippi River. Areas adjacent to Rocky Bayou and south of Satartia, Mississippi, are vulnerable to damages from backwater during more severe floods. Areas along the Mississippi River are subject to inundation during periods of very high stages such as occurred in 1973. Areas of this sort are found at Vicksburg and in the vicinity of Paces Bayou south of Vicksburg. Damages in upstream watersheds in the basin are to agricultural areas. As in other upstream watersheds, flooding is classified as headwater and is due to excessive rainfall and stream overflow, and may be intensified by poorly developed drainage patterns.

The areas subject to flooding and average annual damages resulting from flooding for each of the basins discussed are summarized in table 26. In the presentation of damages, authorized projects that will be initiated by the end of fiscal year 1973 and have a short construction period are considered in place. Projects requiring a long, continuing construction period to provide a significant degree of protection were considered only as the completed portion of the project would effect flooding and damages at the end of fiscal year 1973.

Table 26 - Remaining Flood Problems, Existing Conditions, WRPA 4

Basin	Area subject to Floods (1,000 Acres)		Average Annual Damages due to Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Coldwater														
Headwater Flood	282	188	992	125	731	1,848	2,119	-	233	2,352	3,111	125	964	4,200
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tallahatchie														
Headwater Flood	365	325	1,931	59	957	2,947	3,696	1	352	4,049	5,627	60	1,309	6,996
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yalobusha														
Headwater Flood	153	183	2,583	116	871	3,570	1,227	-	113	1,340	3,810	116	984	4,910
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sunflower														
Headwater Flood	955	913	2,907	737	1,629	5,273	8,094	-	924	9,018	11,001	737	2,553	14,291
Backwater Flood	658	-	1,134	-	144	1,278	-	-	-	-	1,134	-	144	1,278
Yazoo														
Headwater Flood	293	268	807	68	429	1,304	2,370	-	288	2,658	3,177	68	717	3,962
Backwater Flood	66	-	445	260	72	777	-	-	-	-	445	260	72	777
WRPA Total														
Headwater Flood	2,048	1,877	9,220	1,105	4,617	14,942	17,506	1	1,910	19,417	26,726	1,106	6,527	34,359
Backwater Flood	724	-	1,579	260	216	2,055	-	-	-	-	1,579	260	216	2,055
TOTAL						16,997				19,417				36,414

FUTURE DAMAGES

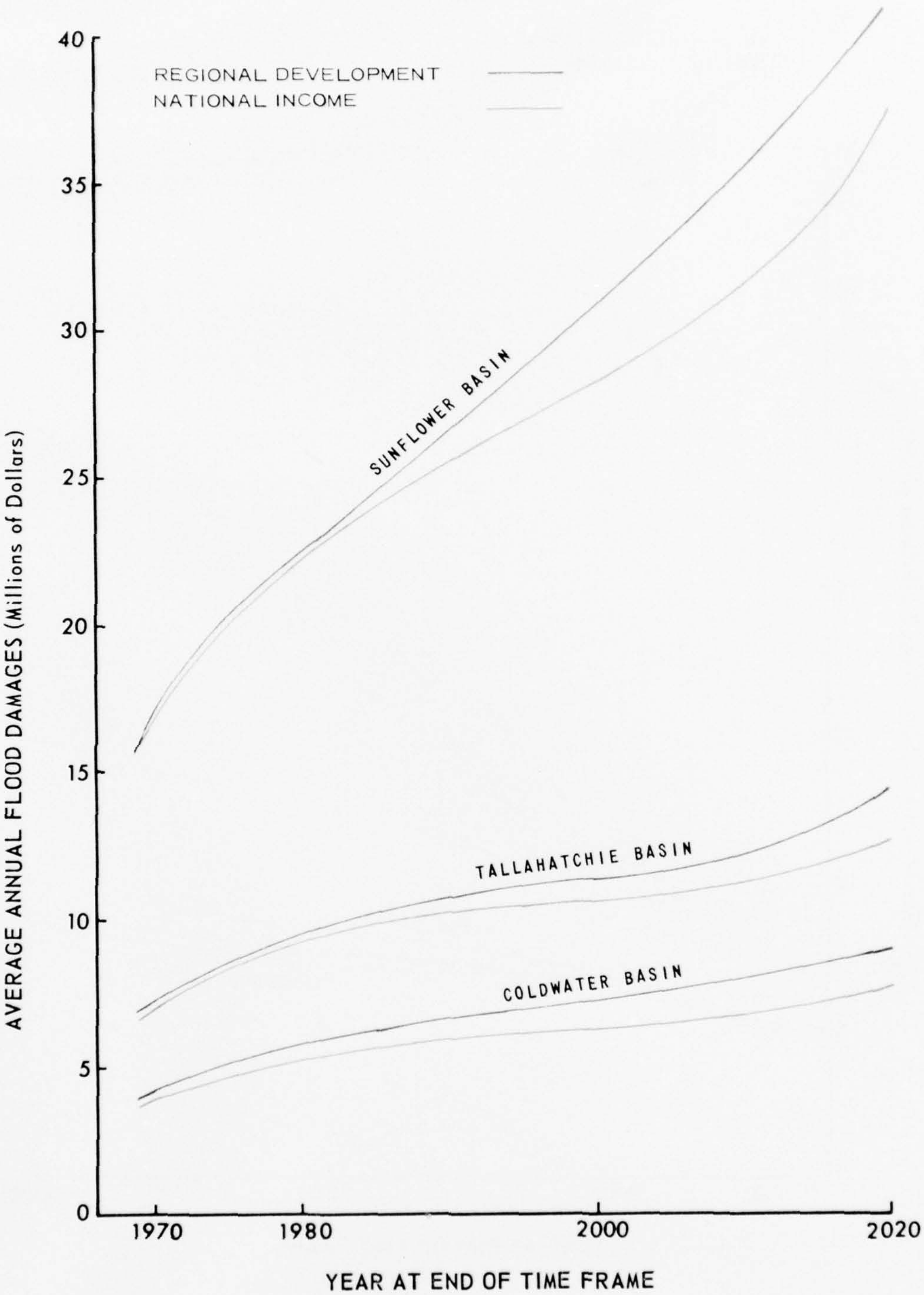
General

Projected future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a slightly higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources.

While the total area subject to flooding under the existing conditions in the WRPA is constant for all time frames, the area subject to flooding in urban and built-up areas increases from 1970 to 2020 under both objectives. The percentage of flooded area occupied by wooded land decreases for the same time span under both objectives. These patterns indicate a trend toward expansion in the floodplain of urban and built-up areas. Figures 12A and 12B illustrate the trends and relative magnitudes of future damages. The distribution of damage by type for each of the two objectives is shown in figure 13.

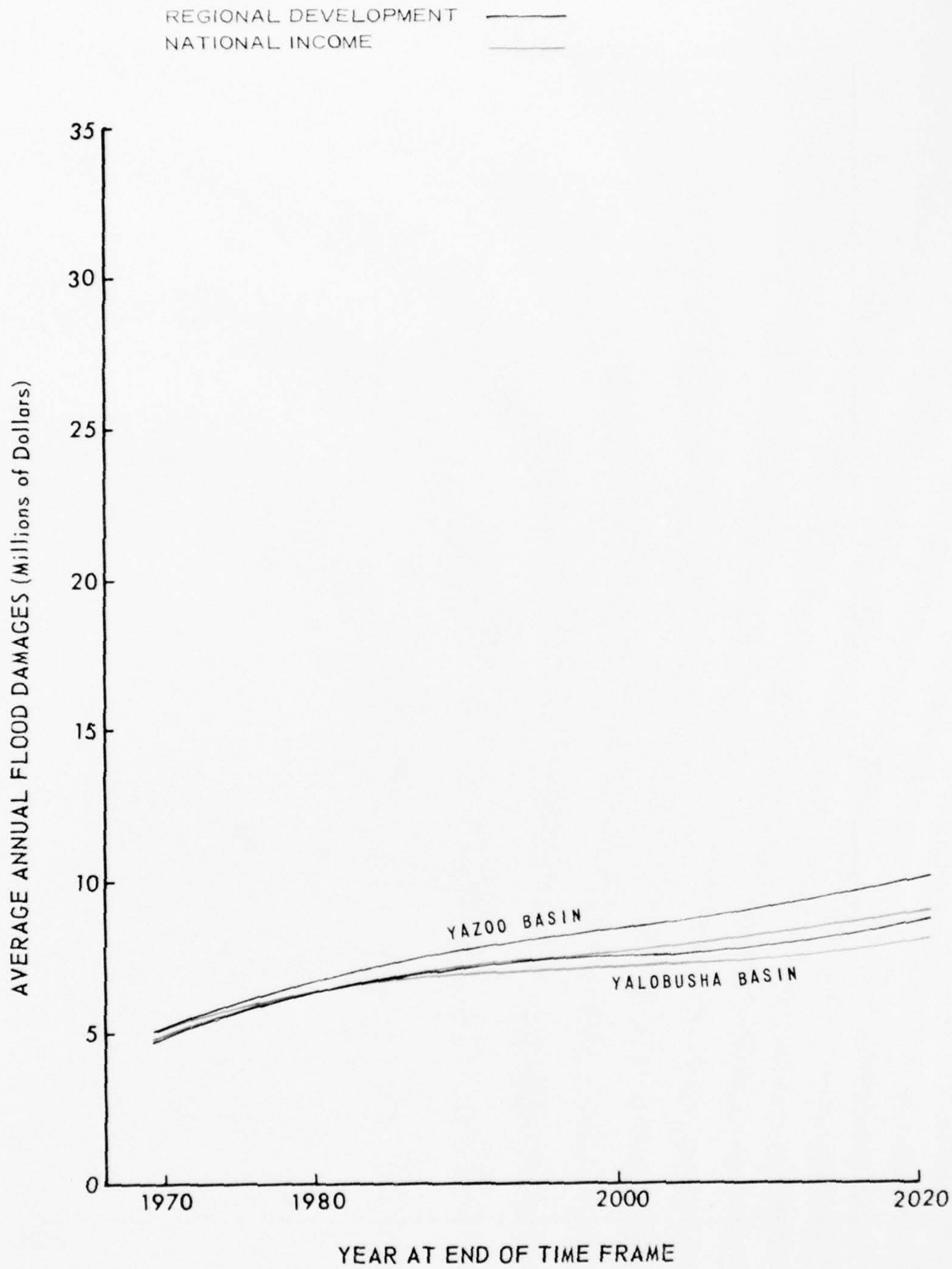
Future Flood Damages with National Income Growth Rate

Under the National Income objective the projected total average annual damage in upstream watersheds increases 124 percent from 1970 to 2020. Along principal streams damages are projected to increase 88 percent for the same period of time. The projected average annual flood damages for upstream watersheds and principal streams under the National Income objective are summarized in table 27.



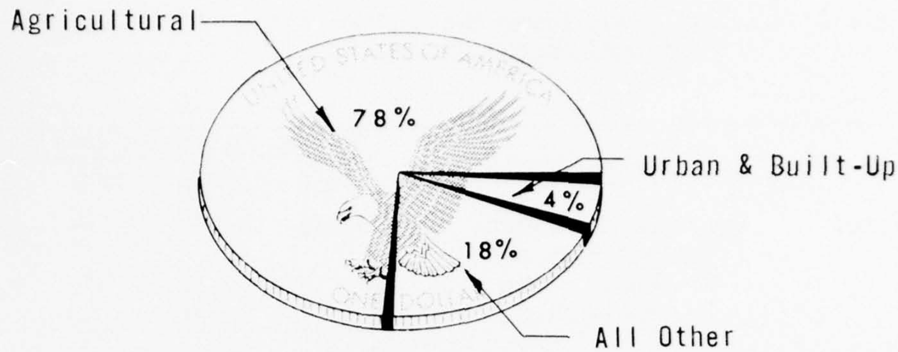
PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-4

Figure 12-a



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-4

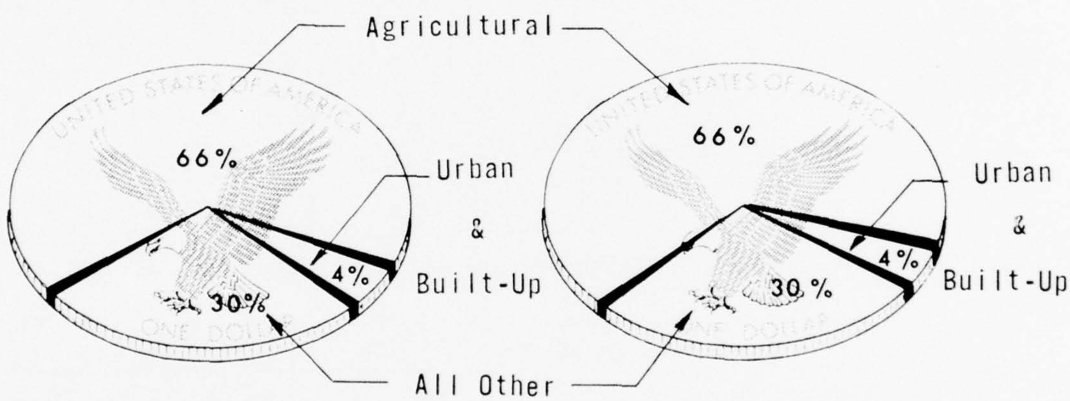
Figure 12-b



1970

NATIONAL INCOME

REGIONAL DEVELOPMENT



2020

DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-4

Figure 13

Table 27 - Existing and Projected Average Annual Flood Damage
National Income Growth, WRPA 4

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Coldwater	Upstream Watersheds	2,352	3,514	4,303	5,273
	Principal Streams				
	Headwater Flood	1,848	2,133	2,458	2,934
	Backwater Flood	0	0	0	0
	Total	4,200	5,647	6,761	8,207
Tallahatchie	Upstream Watersheds	4,049	6,056	7,358	8,918
	Principal Streams				
	Headwater Flood	2,947	3,425	3,759	4,066
	Backwater Flood	0	0	0	0
	Total	6,996	9,481	11,117	12,984
Yalobusha	Upstream Watersheds	1,340	2,005	2,433	2,941
	Principal Streams				
	Headwater Flood	3,570	4,159	4,583	5,056
	Backwater Flood	0	0	0	0
	Total	4,910	6,164	7,016	7,997
Sunflower	Upstream Watersheds	9,018	13,471	16,531	20,326
	Principal Streams				
	Headwater Flood	5,273	6,622	9,511	14,568
	Backwater Flood	1,278	1,651	2,138	2,312
	Total	15,569	21,744	28,180	37,206
Yazoo	Upstream Watersheds	2,658	3,968	4,887	6,041
	Principal Streams				
	Headwater Flood	1,304	1,488	1,625	1,758
	Backwater Flood	777	891	1,108	1,282
	Total	4,739	6,347	7,620	9,081
WRPA Totals	Upstream Watersheds	19,417	29,014	35,512	43,499
	Principal Streams				
	Headwater Flood	14,942	17,827	21,936	28,382
	Backwater Flood	2,055	2,542	3,246	3,594
	Total	36,414	49,383	60,694	75,475

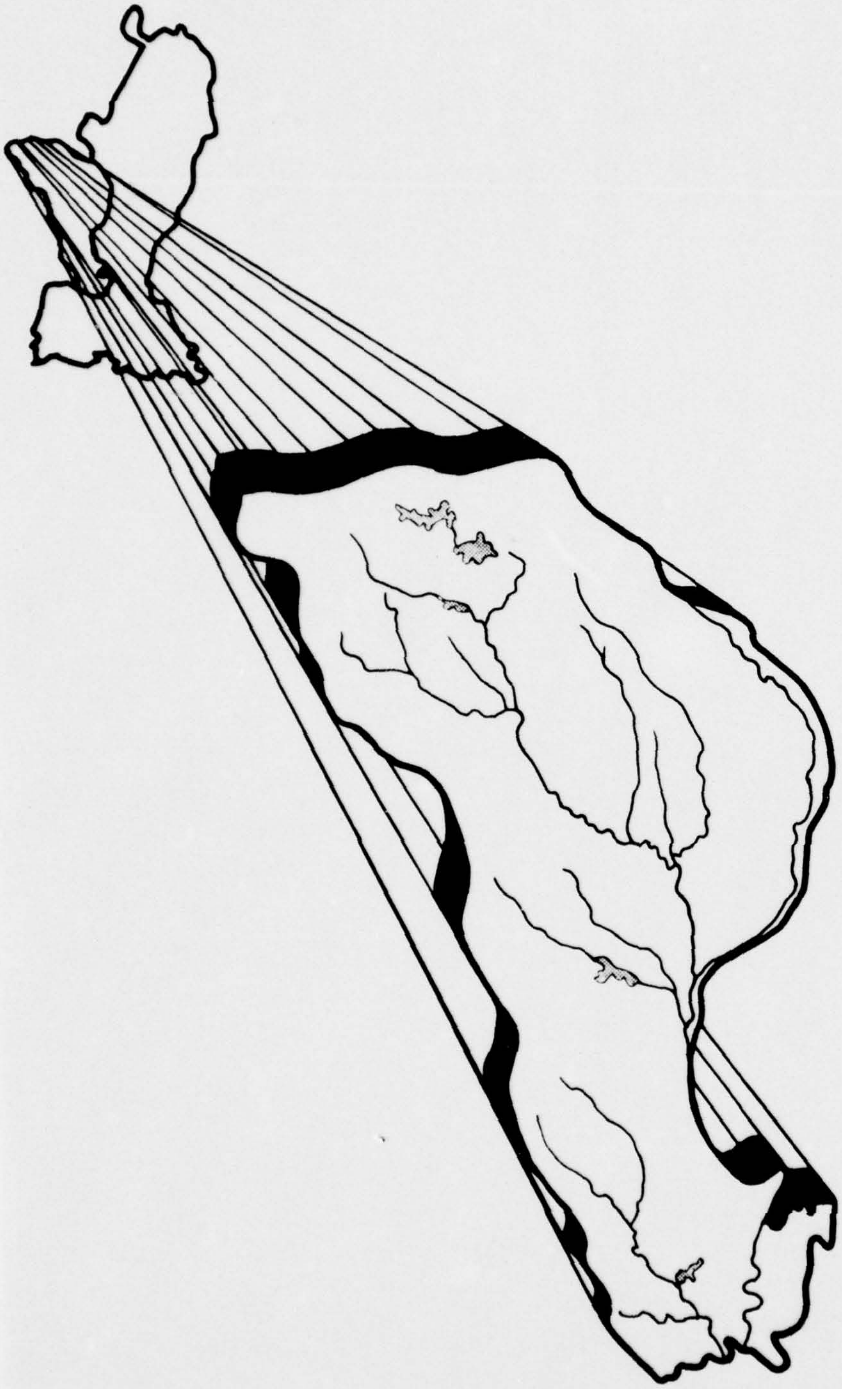
Future Flood Damages with Regional Development Growth Rate

Under the Regional Development objective the projected total average annual damages in upstream watersheds increases 137 percent from 1970 to 2020. Along principal streams damages are projected to increase 113 percent for the same period of time. The projected average annual damages for upstream watersheds and principal streams under the Regional Development objective are summarized in table 28.

Main-stem levees provide flood protection to lowlands near Greenville, Mississippi.

Table 28 - Existing and Projected Average Annual Flood Damage
Regional Development Growth, WRPA 4

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Coldwater	Upstream Watersheds	2,352	3,515	4,546	5,586
	Principal Streams				
	Headwater Flood	1,848	2,205	2,767	3,525
	Backwater Flood	0	0	0	0
	Total	4,200	5,720	7,313	9,111
Tallahatchie	Upstream Watersheds	4,049	6,058	7,780	9,453
	Principal Streams				
	Headwater Flood	2,947	3,540	4,171	4,828
	Backwater Flood	0	0	0	0
	Total	6,996	9,598	11,951	14,281
Yalobusha	Upstream Watersheds	1,340	2,006	2,572	3,117
	Principal Streams				
	Headwater Flood	3,570	4,349	4,924	5,568
	Backwater Flood	0	0	0	0
	Total	4,910	6,355	7,496	8,685
Sunflower	Upstream Watersheds	9,018	13,477	17,462	21,525
	Principal Streams				
	Headwater Flood	5,273	6,801	10,467	16,180
	Backwater Flood	1,278	1,651	2,416	2,616
	Total	15,569	21,929	30,345	40,321
Yazoo	Upstream Watersheds	2,658	3,970	5,161	6,395
	Principal Streams				
	Headwater Flood	1,304	1,542	1,784	2,031
	Backwater Flood	777	905	1,233	1,430
	Total	4,739	6,417	8,178	9,856
WRPA Totals	Upstream Watersheds	19,417	29,026	37,521	46,076
	Principal Streams				
	Headwater Flood	14,942	18,437	24,113	32,132
	Backwater Flood	2,055	2,556	3,649	4,046
	Total	36,414	50,019	65,283	82,254



WRPA 5

W R P A 5

DESCRIPTION

General

WRPA 5 consists of an area containing 20,413 square miles in the States of Arkansas and Louisiana. The drainage area consists of the Ouachita River Basin and the Red River Basin below Hot Wells, Louisiana. The basin is bordered on the east by the western divide of the Boeuf and Tensas River Basins and the Mississippi River main line levees in Concordia Parish, Louisiana. It is bordered on the north by the western divide of the Arkansas River Basin and on the west by the eastern divide of the Red River Basin.

Topography

The terrain varies from the rugged hill areas of the Ouachita Mountains of central Arkansas to the rolling hills and broad plains of south Arkansas and central Louisiana. Elevations in the rugged hill areas vary from 250 to 2,000 feet[1/] while elevations are generally less than 400 feet in the broad plain areas and as low as 35 feet in the low-lying areas of the Red River backwater area.

WRPA 5 is divided into six major hydrologic areas in order to best describe the flooding problems in the area. The six areas are the Ouachita main stem and Bayou D'Arbonne Basin, the Saline River Basin, the Little Missouri River Basin, the Bayou Bartholomew Basin, the Little River Basin, and the Red River backwater area. These drainage areas are shown on figure 14.

The main stem of the Ouachita begins in the steep hills of the Ouachita Mountains near Mena, Polk County, Arkansas, and flows easterly 160 miles through rugged terrain and three lakes to the vicinity of Malvern, Arkansas, thence southward 94 miles through hilly upland to the vicinity of Camden, Arkansas. From there the stream extends southeasterly 132 miles through wide bottoms in a hilly terrain and then southerly 224 miles through the alluvial valley of the Mississippi River to enter the Red River 36 miles above its mouth. It is called the Black River below mile 57 at Jonesville where the Tensas River joins it.

1/ All elevations refer to mean sea level unless otherwise specified.

Bayou D'Arbonne is formed in Union Parish, Louisiana, by the confluence of Corney Bayou and Little Bayou D'Arbonne. The stream has been impounded near its origin to form Bayou D'Arbonne Lake, a single-purpose recreation reservoir. From the reservoir the stream flows through hills in a floodplain about 2 miles wide and enters the Ouachita around mile 190.

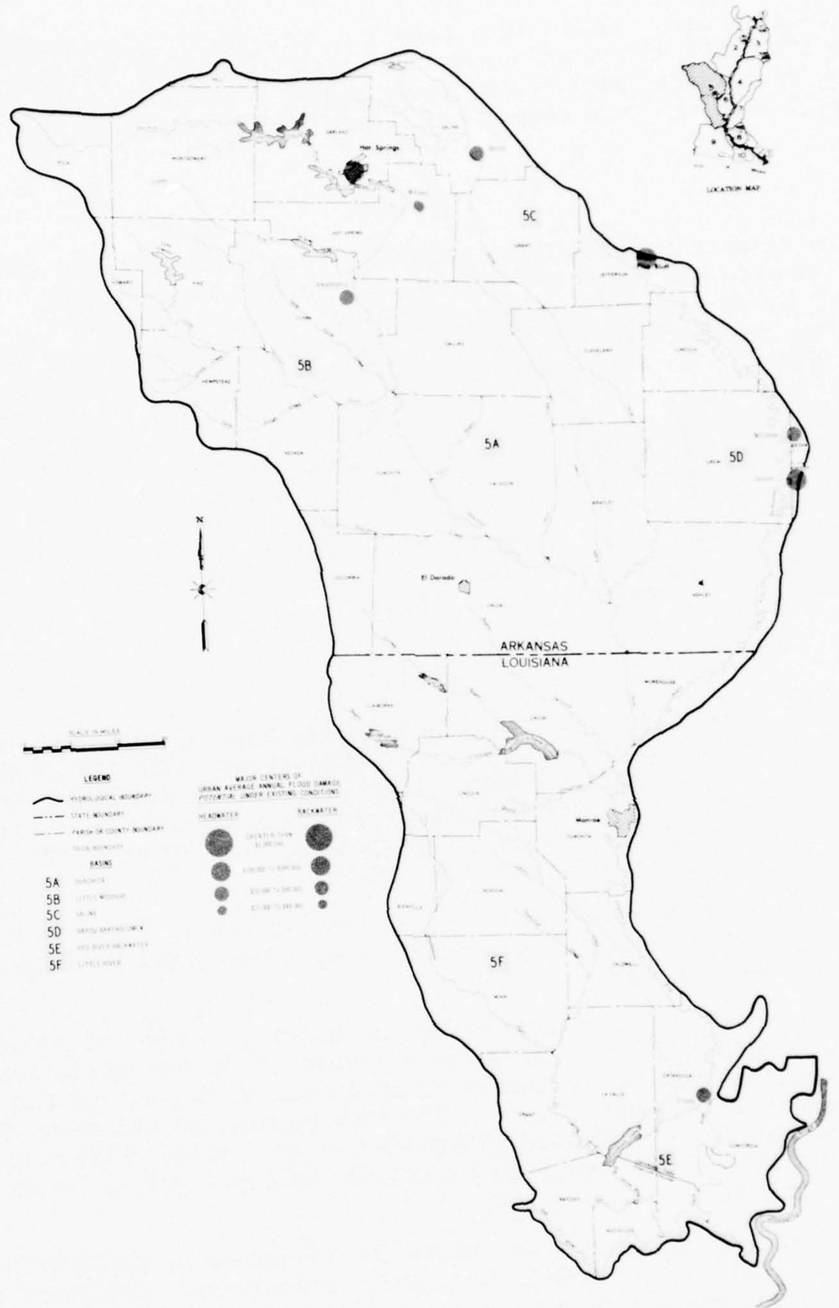
The Saline River Basin lies in south-central Arkansas and has a drainage area of 3,270 square miles. The drainage area consists of 590 square miles in the mountain section of the Ouachita River Basin, 2,550 square miles in the hill section, and 130 square miles in the floodplain. The Saline River is formed in Saline County, Arkansas, by the confluence of headwater streams and flows southerly about 200 miles to join with the Ouachita near Crossett, Arkansas. Tributary creeks include Hurricane, Derriseaux, Big, Hudgeon, and Eagle. Elevations in the basin range from a maximum of 1,900 feet near the source to a minimum of 65 feet near the mouth of the river.

The Little Missouri River has its origin in the southeastern corner of Polk County, Arkansas, on the southern slopes of the Ouachita Mountains and flows in a southeasterly direction a distance of 147 miles to enter the Ouachita River 27.6 miles above Camden, Arkansas. The total drainage area is 2,080 square miles. The major tributaries are Terre Noire and Antoine Creeks from the north and Whiteoak, Terre Rouge, Ozan, and Muddy Fork Creeks from the south.

Bayou Bartholomew, one of the principal east bank tributaries of the Ouachita River, drains 1,718 square miles in eastern Arkansas. It has its origin in Jefferson County, Arkansas, about 10 miles northwest of Pine Bluff, Arkansas, and flows southerly about 370 miles to join the Ouachita upstream from Sterlington, Louisiana. About 644 square miles of land are in the floodplain. The Bayou Bartholomew Basin is separated from the Boeuf and Tensas River Basin by a low divide which contains numerous depressions permitting flow between the basins during periods of high water.

Little River, formed by the confluence of Dugdemona River and Castor Creek, flows southerly 60 miles in a floodplain 1/2 to 3 miles wide between low hills to Catahoula Lake. From the lake it flows 24 miles across the alluvial valley into the Black River. Tributaries include Bear, Fish, and Big Creeks, and Bayou Funny Louis.

The Red River backwater area is located in central Louisiana in portions of Avoyelles, Catahoula, Concordia, LaSalle, and Rapides Parishes that are subject to overflow from backwater originating in the Mississippi River and Red River tributary systems. The area is of low relief with surface elevations ranging from 35 feet to 100 feet along the crest of Macon Ridge near the northern boundary. The principal features of the area are the natural levee ridges along present



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 5 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 14

and ancient courses of the Mississippi River, Macon Ridge which extend in a north-south direction across the northern half of the area, and the shallow basin areas inclosed by these ridges. Catahoula Lake, a shallow ephemeral lake, is in a depression formed by subsidence along a fault line.

Climate

The climate in the basin is generally moderate with the average annual temperature being 65° F. Average monthly temperatures vary from 45° F. in January to 82° F. in July. Prevailing winds are generally from the south and southwest in the summer and north and northwest in the winter. Annual precipitation has varied from 79.6 inches in 1920 to 32.3 inches in 1943, with an average of about 53 inches at Monroe, Louisiana. Storms productive of serious floods in the basin are those due to frontal action between moist tropical maritime and cold polar air masses. Major floods result when series of such storms are peaked by intensive precipitation. Examples of such storms include 29-30 May 1945, when over 9 inches of rain fell in 2 days at Glenwood, Arkansas, and 8-14 May 1968, when over 20 inches fell in the mountain headwaters of the Caddo and Little Missouri Rivers.

Economy

Agricultural land is one of the valuable natural resources of the area. Soybeans and cotton are the principal crops, with the production of livestock also being important. Much of the land classified as agricultural is in forests which provide an important source of income. The most commonly produced minerals are petroleum, sand, gravel, bromine, natural gas, natural gas liquids, and clay.

In 1967 there were a total of 1,599 manufacturing firms in the area. The major manufacturing industries are lumber and furniture, and paper and allied products.

Although WRPA 5 has not experienced the large losses of population that have occurred in other areas as a result of the mechanization of agriculture, its population increases have been below that of the Nation and the Lower Mississippi Region. Its 1970 population was about 822,000 and was almost equally divided between rural and urban. Cities with populations over 25,000 are Pine Bluff, Hot Springs, and El Dorado, Arkansas, and Monroe, Louisiana.

The trend in employment has shown the influence of capital-intensive industries. During the 1950-1960 period, agricultural employment dropped 60 percent, but was not offset by gains in other areas. For the period 1959-1968, the drop in agricultural employment lessened while gains in other areas increased. The result was a reversal of the downward trend in total employment during the 1950's. The per capita income of the area is well below the national average, but has moved steadily upward, a trend which is expected to continue.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in WRPA 5 generally occurs in the winter and spring months and may result from the runoff of a single storm having duration of a few days or a series of storms extending over a period of several months. The occurrence and intensity of flooding are affected by seasonal upstream conditions influencing the Mississippi River as well as local storm conditions and drainage patterns. Flooding in the area can be classified as two distinct types - backwater and headwater flooding.

Mississippi-Red River Backwater Flooding

The Red River backwater area is subject to flooding from backwater originating in the Mississippi and Red River tributary systems. This backwater blocks outlets for streams originating in the interior of WRPA 5, further aggravating flood situations.

Headwater Flooding

Tributary streams are subject to overflow when intense storms cause local and upstream drainage areas to produce runoff in excess of stream capacities. Headwater flooding along principal reaches occurs when precipitation is intense and of a long duration over much of the drainage area of the stream. Flooding in upstream reaches is caused by excessive local runoff and may be increased where local drainage patterns are poorly developed.

Major Historical Floods

1927 Flood

The 1927 flood is regarded by many as the greatest peace-time catastrophe in the history of the United States. Much of the damage in WRPA 5 was the result of backwater that flooded large areas in Louisiana when the Mississippi River levees failed at many points. Heavy rains in Arkansas and Louisiana in April combined with the backwater of the Mississippi to cause streams to reach record stages. Damages in the Arkansas portion of WRPA 5 were approximately $2,700,000 - all due to headwater flooding. Damages in the Louisiana portion were approximately $8,600,000, with much of the damage caused by backwaters of the Mississippi. Much of the damage due to backwater flooding would be prevented today by existing flood protection systems.

1932 Flood

The 1932 flood was the result of heavy rainfall that occurred during the period November 1931 through February 1932 and was centered in

southern Arkansas and northern Louisiana. During the 4-month period, several stations reported a total of 51 inches of rainfall, about the normal yearly total for the area. The flood produced a record discharge on the Ouachita River at Monroe of 101,000 c.f.s. The maximum discharge at Camden, Arkansas, was 102,000 c.f.s. Approximately 434,000 acres were flooded in the Ouachita Basin.

1937 Flood

The floods of 1937 were widespread on the Mississippi River and its tributaries. The floods on the Ouachita occurred during January and February of 1937. Headwater flooding in the Ouachita Basin inundated 705,000 acres, while backwater flooding in the Red and Ouachita Basins inundated 1,248,000 acres. Discharges on some streams were as large as the 1927 flood, but extensive levee and flood protection systems built after 1927 along the Mississippi River prevented much of the damage.

1945 Flood

The 1945 flood resulted from heavy rainfall during the period of 28 March through 2 April 1945, with several stations recording over 10 inches. The major portion of the flood originated above Camden, Arkansas. Maximum discharges were 243,000 c.f.s. at Camden, Arkansas, and 100,000 c.f.s. at Monroe, Louisiana (both stations on the Ouachita River). The stage of 30.3 feet and discharge of 170,000 c.f.s. were both records for the Ouachita at Arkadelphia, Arkansas. This flood occurred before the construction of Blakely Mountain, Narrows, and DeGray Dams, which would have reduced flood damages significantly.

1958 Flood

Excessive rains in late April and early May led to the floods of 1958 in WRPA 5. Rains continued in May to prolong the period of overflow. A total of 2,476,000 acres were flooded in the Ouachita Basin (467,000 cleared). Every highway in Louisiana north of U.S. Highway 80 (Shreveport to Monroe) and west of U.S. Highway 165 north from Monroe was closed at some point. Flood damages for the Arkansas portion of WRPA 5 totaled $2,075,000. Damages in the Louisiana portion of WRPA 5 including the Black and Red Rivers below Alexandria, Louisiana, totaled $2,952,000. Many streams in Louisiana experienced their record maximum discharge during the flood. Three lives were lost in Louisiana as a result of flooding.

1968 Flood

Hailstorms in late April were followed by severe weather of one form or another in May. Particularly heavy rains from 8 May through 14 May helped produce spectacular totals for the month of over 20 inches in the mountain headwaters of the Caddo and Little Missouri Rivers. Extremely heavy rains of up to 10 inches on 13 and 14 May produced record stages on some streams. Most of the damage was in the Arkansas portion of WRPA 5 with 19 counties reporting damage. Three Louisiana parishes reported damage. Approximately 1,050,000 acres were flooded. Total damage in the Arkansas section was estimated to be $11,430,000. Total damage in the Louisiana section was estimated to be $1,952,000.

1973 Flood

Flooding conditions began in late September 1972 when torrential rains of up to 12 inches were deposited over the Upper Ouachita, Little Missouri, and Caddo Rivers. Although estimated to exceed 100-year-frequency rainfall amounts, only minor damage to some lowland areas resulted. October rains of 3 to 5 inches above normal hampered fall harvesting operations. November rainfall was again heavy and losses to unharvested crops and to public roads and bridges soared. Rains continued through December, January, and February, setting the stage for the flooding that was to follow.

Three significant storm systems passed over the WRPA during the month of March. These heavy rains caused local lowland flooding while maintaining streams at or above flood stage from Arkadelphia, Arkansas, to Jonesville, Louisiana. Rainfall was less than normal during early April but heavy storms hit the area during 19-24 April. Property damage from flash flooding and overbank flooding as well as windstorm damage was common. Rainfall amounts greater than three times the monthly normal left thousands of acres of farm and timberland under water.

Over 1.3 million acres were inundated as the result of headwater flooding -- about 1 million acres of which were wooded. Total damages due to headwater flooding were estimated at $27.7 million with 91.2 percent of the total agricultural, 6.7 percent road and bridge, 1.6 percent urban, and 0.5 percent other.

Although damage to headwater areas was high, hardest hit was the Red River Backwater Area as high stages on the Mississippi, Red, and Atchafalaya Rivers restricted the natural drainage from the headwater streams. The area experienced near record stages, but more harmful was the record duration of the flood. The length of the flooding was particularly distressing to people forced from their homes and to farmers who could not prepare their fields for planting.

Over 523,000 acres were flooded in backwater areas with about 223,000 acres of this cleared land. Damages due to backwater flooding were estimated at $39.5 million with 89.3 percent of this agricultural 5.4 percent road and bridge,2.5 percent urban, and 2.8 percent other.

The Flood of 1973 will be recorded as one of the most devastating in recent history in the Ouachita Basin. Residents of the area have long remembered the floods of 1927 and 1937 -- now the Flood of 1973 will be deeply imbedded in their memory.

Flood damage in Red River Backwater Area near Jonesville, Louisiana, 1973.

Failure of Louisiana Department of Public Works levee which protected 10,000 acres of prime farm land and 50 homes in Red River Backwater Area, 1973.

PRESENT FLOOD PREVENTION PROGRAM AND REMAINING DAMAGES

Existing Program

Structural Program

The Flood Control Acts of 18 August 1941 and 22 December 1944 and the Flood Control and Rivers and Harbors Act of 17 May 1950 provide for a comprehensive plan of improvement for flood control, power, and other purposes for the Ouachita River and tributaries. Three reservoirs planned as part of the comprehensive plan of improvement for the Ouachita Basin have been constructed. These are on the Ouachita River, the Little Missouri River, and the Caddo River. Table 29 gives data for flood control storage in WRPA 5.

Local flood protection on the right bank of the Ouachita River and local protection work on the left bank of Bayou Bartholomew and the Ouachita River between Bastrop and Monroe were constructed under the project "Mississippi River and Tributaries." Levees have been constructed at various locations on the left bank below Monroe under provisions of Section 6 of the Flood Control Act approved 15 May 1928. Protection to the alluvial valley of the Ouachita River is provided by levees on the Arkansas south bank and the Mississippi west bank levees. Channel improvements have been completed on several tributary streams in Arkansas. Table 30 gives a summary of local protection works for WRPA 5.

Organized districts have constructed drainage improvements in the Little Missouri River Basin and in the Bayou Bartholomew Basin. Farm improvements for the retardation of runoff and erosion prevention have been implemented. Small reservoirs constructed on tributaries by Federal, State, and other agencies for water supply, recreation, and conservation of wildlife are not major factors in the control of main stem floods but do help in reducing local runoff. Table 29 summarizes storage potential for these small reservoirs.

Small watershed projects less than 250,000 acres in size provide protection from floods in the upstream reaches. Five of these projects are currently in operation in WRPA 5. Flood protection by these projects is provided in the Ouachita River Basin, in the Little Missouri Basin, and in the Lower Red River Basin. Additional information about the structural flood control program is contained in Appendix D, Inventory of Facilities.

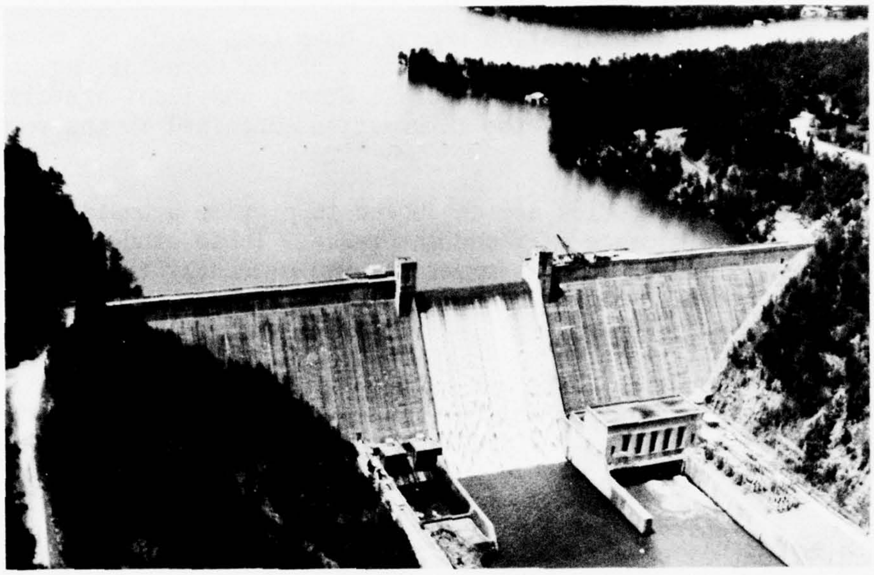
Table 29 - Flood Control Storage, 1970, WRPA 5

Basin	Major Reservoir	Small Reservoir	Totals
	Flood Control - Storage in 1,000 Acre-Feet		
Ouachita Main Stem	844.2	23.6	867.8
Little Missouri River	128.2	17.3	136.7
Saline River	0	0	0
Bayou Bartholomew	0	0	0
Red River Backwater	0	0	0
Little River	0	0	0
Total	972.4	40.9	1,004.5

Table 30 - Summary of Local Protection Projects, 1970, WRPA 5 1/

Basin	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Ouachita Main Stem	115.7	2.1	4	385
Little Missouri River	0	146.4	0	-
Saline River	0	0	0	-
Bayou Bartholomew	6.6	10.6	0	-
Red River Backwater	140.2	277.1	1	180
Little River	0	0	0	-
Total	262.5	436.2	5	565

1/ Consists of projects in both upstream watersheds and principal reaches.



Narrows Dam reducing flood stages on Little Missouri River during 1968 flood.

Land Treatment

Over 3 million acres in WRPA 5 have been adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. This land treatment results not only from local, State, and Federal group efforts, but also from individual landowner's efforts. Additional data on land treatment is included in Appendix F, Land Resources. Data on acres with adequate treatment by basin are shown on table 31.

Table 31 - Land Treatment, 1970, WRPA 5

Basin	Lands Adequately Treated Acres (1,000's)
Ouachita Main Stem	1,306
Little Missouri River	321
Saline River	442
Bayou Bartholomew	316
Red River Backwater	283
Little River	389
Total	3,057

Nonstructural Program

Nine Flood Plain Information reports have been completed or are underway in WRPA 5. The Vicksburg District of the Corps of Engineers provides technical assistance to Federal, State, and local agencies in the interpretation and use of the information contained in the reports.

Flood Insurance

Flood Insurance studies are conducted to provide a basis for rate determination and issuance of flood insurance. These studies constitute another source of floodplain information, and presently two such studies have been completed or are underway in WRPA 5.

Flood Forecasting

River and flood forecasts for the Louisiana portion of WRPA 5 are provided by the U.S. Weather Bureau office at New Orleans, Louisiana. Forecasts for the Arkansas portion are provided by the United States Weather Bureau station at Little Rock, Arkansas. The area is under surveillance by U.S. Weather Bureau radar, which effectively detects severe weather and excessive rainfall. The news media of the area have access to the NOAA Weather Wire Service which distributes weather and river information.

Emergency Operations

The Federal, State, and local agencies have cooperated on numerous occasions when natural disasters such as tornadoes and floods have occurred. Emergency operations performed in the past have included evacuation and assistance to reduce loss of life in threatened areas, all phases of flood-fighting activities, and recovery operations.

Remaining Flood Problems

Most flood problems in WRPA 5 are agricultural, with substantial damage to urban areas and public improvements from major floods. Tributaries entering the Ouachita River above the mouth of Bayou Bartholomew experience both intense flash floods and extreme low flows. Flooding on several streams is confined mostly to undeveloped wooded areas and causes little damage. With the gradual extension of clearing into the low lands adjoining the previously developed higher stream banks, and the conversion of these lowlands to agricultural uses, damages from the lesser floods are progressively increasing.

While overbank flooding was evaluated for all urban areas, damages due to excessive local runoff were not. Figure 14 shows major centers of urban flood damage.

Total upstream damages for WRPA 5 are almost twice the magnitude of damages on principal reaches. Over 2-1/2 million acres are subject to flooding in upstream watersheds. Of the total upstream damage for WRPA 5, about 88 percent is agricultural and about 11 percent is to

roads and bridges, with the remaining to urban or built-up areas. The areas comprising WRPA 5 have the following percentages of the total for average annual upstream damage: Bayou Bartholomew - 61.4 percent, Lower Red - 16.1 percent, Ouachita - 9.3 percent, Little Missouri - 7.0 percent, Little River - 3.6 percent, and Saline - 2.6 percent.

Much of the floodplain of the Ouachita River below the approximate latitude of Bastrop, Louisiana, is protected by the Ouachita River levees. The floodplain bordering the Ouachita from the approximate latitude of Malvern, Arkansas, south to the levees near Bastrop is subject to overflow from the main stem. Particular problem areas on the Ouachita main stem are parts of Clark County, Dallas County, Ouachita County, and Calhoun County in Arkansas, and parts of Union Parish and Morehouse Parish in Louisiana. Damages are also sustained on several tributary streams, the major ones being Smackover Creek, Moro Creek, and Bayou DeLoutre. Several urban areas on the Ouachita River and its minor tributaries sustain damage from overbank flooding. The major ones are Malvern, Arkansas; Arkadelphia, Arkansas; and Trinity, Louisiana. Hot Springs, Arkansas, has a flooding problem due to interior runoff. The upstream damage of the Ouachita River and its minor tributaries is 83 percent agricultural, 6 percent urban and built-up, and 11 percent to public improvements.

Flood waters cause bridge failure on Caddo River, 1968 flood.

Flash flooding on the Little Missouri River and its tributaries frequently occurs. The majority of the damage is agricultural, with substantial damage to roads and bridges and urban areas during major floods. Particular problem areas are the main stem below Ozan Creek and Terre Noire Creek. Most of the upstream damage is agricultural, with substantial damage to public improvements.

The Saline River Basin is subject to frequent headwater overflow, with some portions of the basin flooded several times a year. In addition, the lower portion is subject to headwater flooding from the Ouachita River. Over 60 percent of the average annual damage is to farm non-crop or public improvements, with most of the remaining damage agricultural. Benton, Arkansas, sustains substantial urban damage. Of the tributary streams, Hurricane Creek sustains the highest magnitude of damage. Of the upstream damage in the Saline Basin, 84 percent is agricultural, 15 percent is to public improvements, and less than 1 percent is to urban and built-up areas.

Agricultural flood damage, Little Missouri Basin, 1968.

Damages in the Bayou Bartholomew Basin are substantial to public improvements, urban areas, and agriculture, with agricultural damage prevalent throughout the length of the basin. Urban areas with overbank

flooding problems are McGehee, Dermott, and Pine Bluff, Arkansas. McGehee and Dermott are damaged only with occurrence of major floods. Pine Bluff has serious interior runoff problems. Upstream damages for the Bayou Bartholomew Basin are high, comprising 87 percent of the total damages for the basin and 61 percent of the upstream damages in WRPA 5. Most of the upstream damage in the basin is agricultural, with the remaining to public inprovements.

Damages in the Little River Basin are primarily agricultural, with some damage to urban and built-up areas. Overbank flooding damages on Castor Creek and the Dugdemona River are mostly agricultural, with some urban damage in Winnfield, Louisiana. Upstream damages in the Little River Basin are mostly agricultural, with substantial damage to urban built-up areas and to public improvements.

The Red River backwater area is subject to severe backwater flooding as well as lesser flooding from storms in the interior. Agricultural damage, which occurs to some extent almost yearly, comprises 75 percent of the total damage, with substantial damage to public improvements and some damage to built-up areas. All of the upstream damage in the area is agricultural.

Table 32 shows acres subject to flooding and the average annual damage for WRPA 5. For evaluation of damages, authorized projects initiated by the end of fiscal year 1973 and having a short construction period were considered in place. Projects requiring a long, continuing construction period were considered only as their completed portions would affect flood damages at the end of Fiscal Year 1973.

Urban damage - Arkadelphia, Arkansas, 1968 flood.

Table 32- Remaining Flood Problems, (1970), Existing Conditions, WRPA 5

Basin	Area subject to Floods (1,000 Acres)		Average Annual Damages due to Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Ouachita Main Stem														
Headwater Flood	644	709	1,070	243	528	1,841	1,014	72	136	1,222	2,084	315	664	3,063
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Little Missouri River														
Headwater Flood	147	162	638	0	642	1,280	740	1	176	917	1,378	1	818	2,197
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saline River														
Headwater Flood	225	398	257	81	544	882	290	3	52	345	547	84	596	1,227
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bayou Bartholomew														
Headwater Flood	358	333	444	648	128	1,220	6,968	0	1,105	8,073	7,412	648	1,233	9,293
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Red River Backwater														
Headwater Flood	-	877	-	-	-	-	2,111	-	-	2,111	2,111	-	-	2,111
Backwater Flood	557	-	1,270	48	341	1,659	-	-	-	-	1,270		341	
Little River														
Headwater Flood	107	188	213	22	12	247	411	39	26	476	624	61	38	723
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRPA Total														
Headwater Flood	1,481	2,667	2,622	994	1,854	5,476	11,534	115	1,495	13,144	14,156	1,109	3,349	18,614
Backwater Flood	557	-	1,270	48	341	1,659	-	-	-	- -	1,270	48	341	1,659
TOTAL						7,129				13,144				20,273

FUTURE DAMAGES

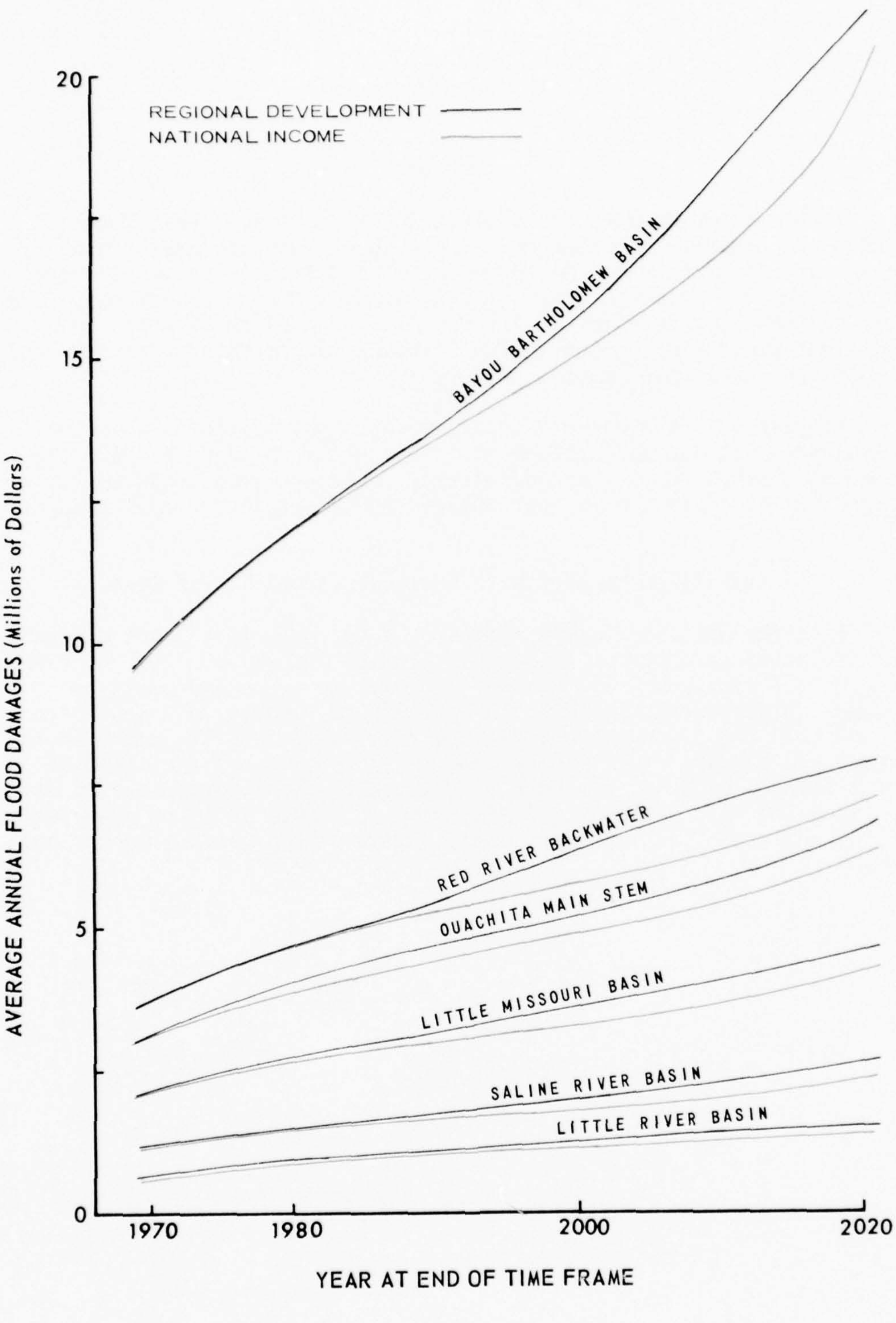
General

Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a level of economic development that would improve the region's industrial advantage and more fully utilize the available natural resources.

Projections show a trend toward greater use of floodplains for urban and agricultural development. This shift in land use plus the expected further development of already developed areas resulted in a large increase from the present damages to the projected 2020 damages.

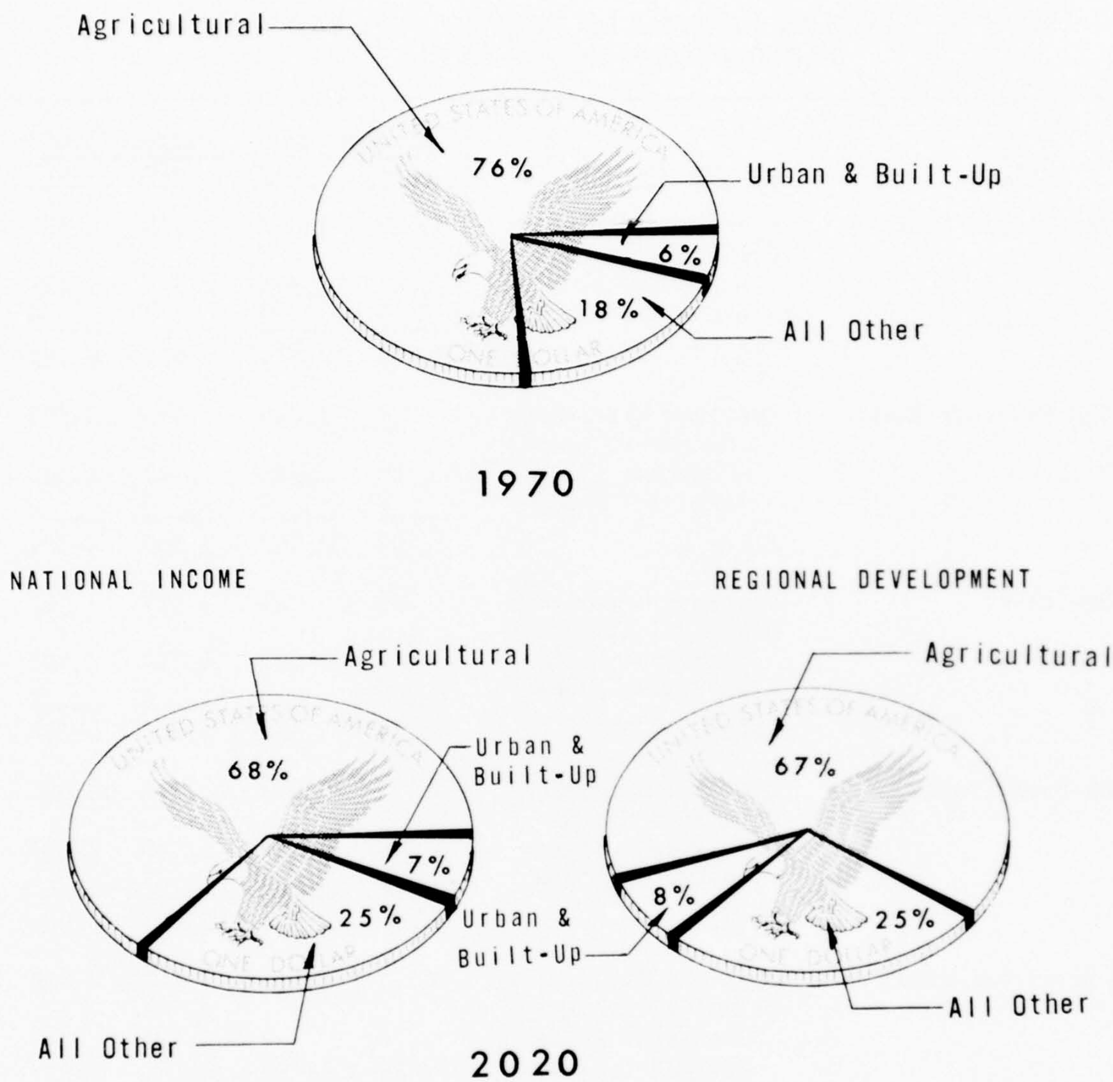
Future Flood Damages with National Income Growth Rate

With the National Income approach, total principal reach damage was projected to increase 74 percent from 1970 to 2020. This increase was characterized by a 138 percent increase in urban and built-up damages, a 67 percent increase in agriculture damage, and a 57 percent increase in other damages. Total upstream damage was projected to increase 120 percent from 1970 to 2020. Figure 15 shows the trend of total damages by basin for WRPA 5. Figure 16 shows percentage of damage by types for 1970 and the 2020 projections. Table 33 lists base year (1970) and projected levels of annual damages by principal basins and causes.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-5

Figure 15



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-5

Figure 16

Table 33 - Existing and Projected Average Annual Flood Damage
National Income Growth, WRPA 5

Basin	Delineation	Average Annual Damages ($1000) 1970	1980	2000	2020
Ouachita Main Stem	Upstream Watersheds	1,222	1,613	2,126	2,856
	Principal Streams				
	Headwater Flood	1,841	2,061	2,508	3,283
	Backwater Flood	0	0	0	0
	Total	3,063	3,674	4,634	6,139
Little Missouri River	Upstream Watersheds	917	1,210	1,615	2,201
	Principal Streams				
	Headwater Flood	1,280	1,492	1,745	2,100
	Backwater Flood	0	0	0	0
	Total	2,197	2,702	3,360	4,301
Saline River	Upstream Watersheds	345	455	595	793
	Principal Streams				
	Headwater Flood	882	999	1,212	1,563
	Backwater Flood	0	0	0	0
	Total	1,227	1,454	1,807	2,356
Bayou Bartholomew	Upstream Watersheds	8,073	10,654	13,794	18,103
	Principal Streams				
	Headwater Flood	1,220	1,347	1,501	1,803
	Backwater Flood	0	0	0	0
	Total	9,293	12,001	15,295	19,906
Red River Backwater Area	Upstream Watersheds	2,111	2,789	3,342	3,930
	Principal Streams				
	Headwater Flood	0	0	0	0
	Backwater Flood	1,659	1,988	2,636	3,322
	Total	3,770	4,777	5,978	7,252
Little River	Upstream Watersheds	476	628	814	1,068
	Principal Streams				
	Headwater Flood	247	253	282	317
	Backwater Flood	0	0	0	0
	Total	723	881	1,096	1,385
WRPA Totals	Upstream Watersheds	13,144	17,349	22,286	28,951
	Principal Streams				
	Headwater Flood	5,470	6,152	7,248	9,066
	Backwater Flood	1,659	1,988	2,636	3,322
	Total	20,273	25,489	32,170	41,339

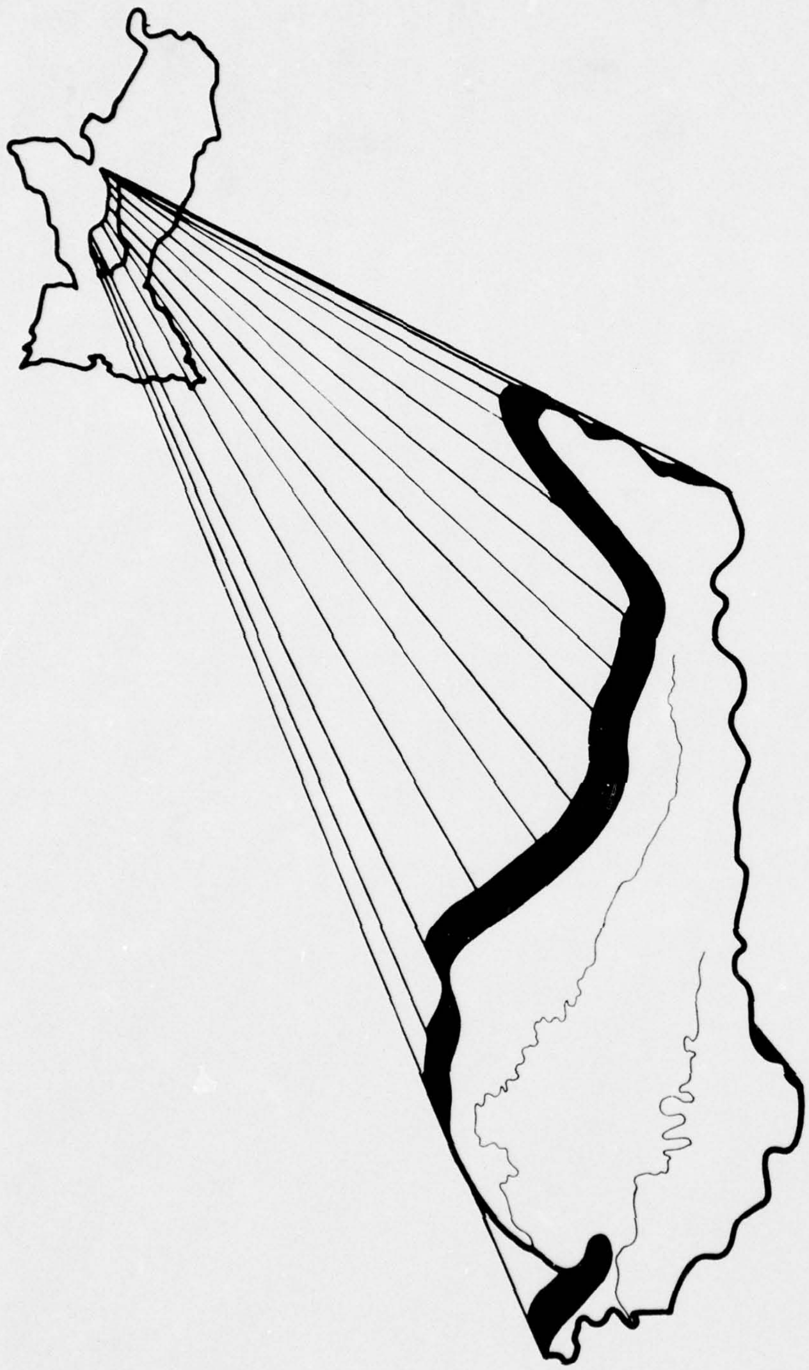
Future Flood Damages with Regional Development Growth Rate

With the Regional Development approach, total principal reach damages increased 88 percent from 1970 to 2020. This increase was characterized by a 174 percent increase in urban or built-up damages, a 76 percent increase in agricultural damage, and a 72 percent increase in other damages. Total upstream damage was projected to increase 128 percent from 1970 to 2020. Table 34 lists base year (1970) and projected levels of annual damages by subareas and causes for the Regional Development approach.

1932 flood conditions at West Monroe, Louisiana.

Table 34 - Existing and Projected Average Annual Flood Damage
Regional Development Growth, WRPA 5

Basin	Delineation	Average Annual Damages ($1000) 1970	1980	2000	2020
Ouachita Main Stem	Upstream Watersheds	1,222	1,620	2,276	2,956
	Principal Streams				
	Headwater Flood	1,841	2,123	2,701	3,568
	Backwater Flood	0	0	0	0
	Total	3,063	3,743	4,977	6,524
Little Missouri River	Upstream Watersheds	917	1,216	1,751	2,278
	Principal Streams				
	Headwater Flood	1,280	1,516	1,831	2,253
	Backwater Flood	0	0	0	0
	Total	2,197	2,732	3,582	4,531
Saline River	Upstream Watersheds	345	457	647	821
	Principal Streams				
	Headwater Flood	882	1,019	1,324	1,716
	Backwater Flood	0	0	0	0
	Total	1,227	1,476	1,971	2,537
Bayou Bartholomew	Upstream Watersheds	8,073	10,692	15,001	18,750
	Principal Streams				
	Headwater Flood	1,220	1,390	1,633	1,963
	Backwater Flood	0	0	0	0
	Total	9,293	12,082	16,634	20,713
Red River Backwater Area	Upstream Watersheds	2,111	2,789	3,486	4,081
	Principal Streams				
	Headwater Flood	0	0	0	0
	Backwater Flood	1,659	1,988	2,842	3,578
	Total	3,770	4,787	6,328	7,659
Little River	Upstream Watersheds	476	631	860	1,107
	Principal Streams				
	Headwater Flood	247	266	302	335
	Backwater Flood	0	0	0	0
	Total	723	897	1,162	1,442
WRPA Totals	Upstream Watersheds	13,144	17,405	24,021	29,993
	Principal Streams				
	Headwater Flood	5,470	6,314	7,791	9,835
	Backwater Flood	1,659	1,988	2,842	3,578
	Total	20,273	25,717	34,654	43,406



W
R
P
A
6

W R P A 6

DESCRIPTION

General

WRPA 6 is composed of about 5,520 square miles located in southeast Arkansas and northeast Louisiana (see figure 17). The west bank levee of the Mississippi River is the east boundary, while the west boundary of the WRPA is the eastern divide of the Ouachita River Basin. The WRPA extends southward from the south bank levee of the Arkansas River to the vicinity of the south boundary of Tensas Parish, Louisiana. The WRPA is about 190 miles long with an average width of 30 miles.

Topography

Generally, the terrain consists of alluvial lands dotted by swamps, bayous, and other poorly drained areas. Elevations 1/ in the WRPA vary from about 55 feet in the southern portion to about 140 feet near the northern end of Macon Ridge, a low ridge which bisects the WRPA north to south from near Eudora, Arkansas, to the vicinity of Sicily Island, Louisiana.

Bastrop Ridge, which is similar to Macon Ridge, lies in the western portion of WRPA 6 and extends from about 10 miles above Bastrop, Louisiana, to the vicinity of Monroe, Louisiana. It varies in elevation from about 15 to 25 feet higher than the surrounding alluvial lowlands.

The drainage of WRPA 6 is handled by the basins of two principal streams, the Boeuf and Tensas Rivers, and the area has been divided into two hydrologic areas corresponding to these basins as shown in figure 17.

The Boeuf River Basin, with a drainage area of about 2,910 square miles, is drained by the Boeuf River and a network of natural and artificial tributaries which, due to the relatively flat terrain, become interconnected during periods of high runoff in the basin. The streams of the basin flow generally in a southerly direction from Jefferson County, Arkansas, about 180 miles to the confluence of the Boeuf and Ouachita Rivers.

The main drainage system of the Boeuf River Basin consists of Boeuf River, Bayou Lafourche, Big and Colewa Creeks, Canal 19, Big Bayou, Canal 18, Fleschmans Bayou, Caney Bayou, Black Pond Slough, and Kirsch Lake Canal.

1/ All elevations refer to mean sea level unless otherwise specified.

The Tensas River Basin with a drainage area of about 2,610 square miles contains Bayou Macon, the Tensas River, and several other natural and constructed tributaries which become interconnected during high run-off periods.

The Tensas River Basin parallels and has generally the same dimensions as the Boeuf River Basin and lies between the Boeuf River Basin and the Mississippi River west levee. Its main drainage system includes Tensas River, Bayou Macon, Canal 43, Canal 81, Mill and Vidal Bayous, and Rush Bayou.

Climate

WRPA 6 experiences a climate characterized by mild winters and hot summers. Temperatures in the area range from monthly averages of 48° F. in the winter to 81° F. in the summer, with the average annual temperature being 65° F. This climate produces a frost-free growing season of about 7-1/2 months.

Rainfall over the area is normally uniform with an average of 52 inches occurring annually. Recorded annual rainfall extremes range from 36 inches in 1924 to 68 inches in 1923. Average monthly rainfall throughout the year varies from about 3 to 6 inches, with more than 4 inches per month occurring from November through May, as heavy winter and spring rains are characteristic of the WRPA.

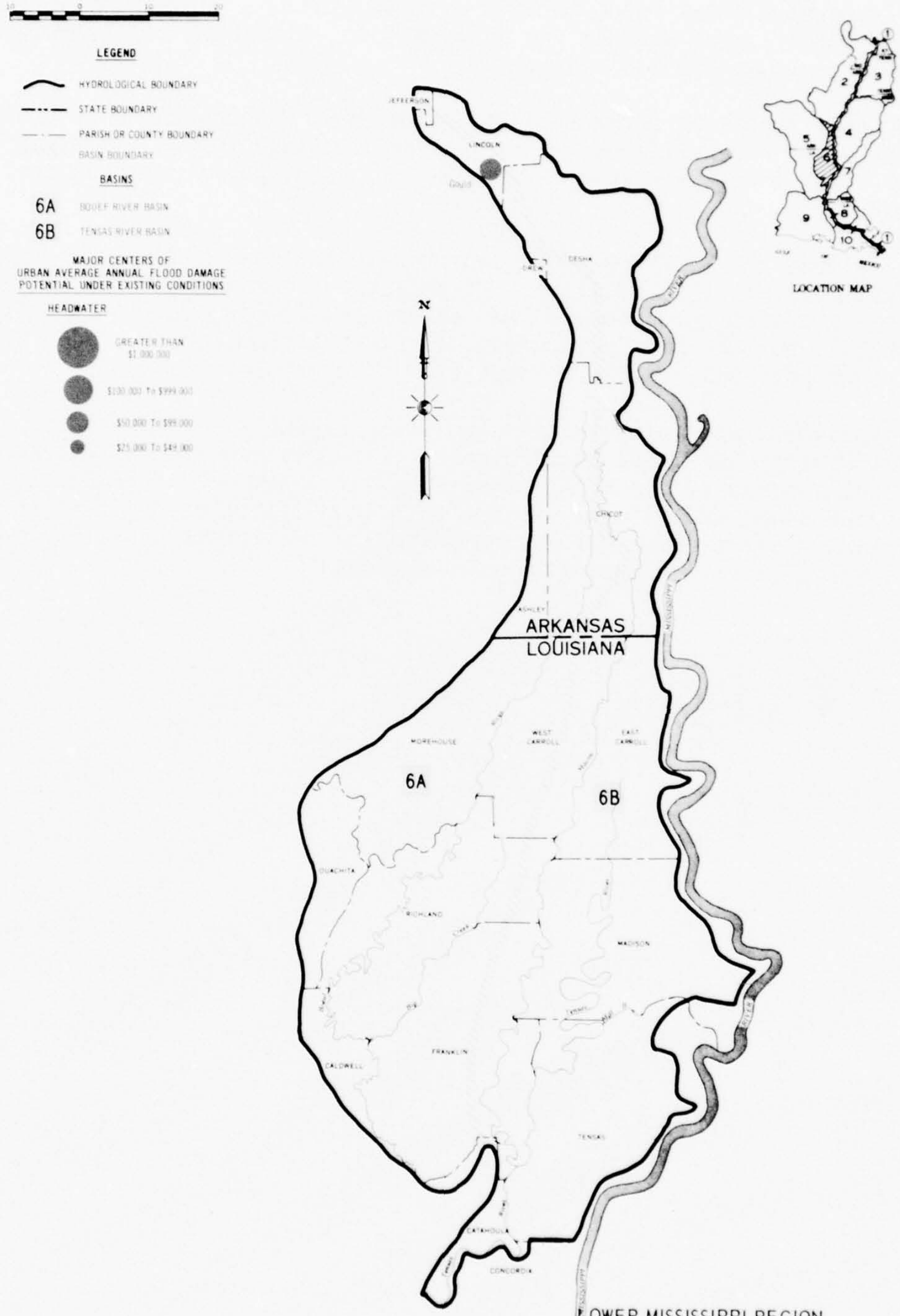
Rainfall records from 1886 to the present show that storms of sufficient magnitude to produce significant flood damages along the principal streams in the area in their unimproved state have occurred on an average of about once in 3 years. Tributary streams experience damaging floods at an even higher frequency of occurrence.

Economy

In 1970 the population of WRPA 6 was about 188,000, a 5 percent decrease since 1959. Of this total, 39 percent was urban and 61 percent was rural. Principal cities in the WRPA are Bastrop and Tallulah, Louisiana, with 1970 populations of 14,713 and 9,643, respectively.

Per capita income for WRPA 6 has increased steadily; however, it remains lower than the United States per capita income. In 1968 the area per capita income was $1,960, or 59.4 percent of the national per capita income.

Highly fertile soil is the WRPA's most valuable resource, with agricultural pursuits using 56 percent of the land area. The principal products are cotton, rice, corn, soybeans, small grains, beef, and



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 6 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 17

timber, with a total value in 1970 of $144 million. Of this total, production of crops account for $128 million; livestock and livestock products account for $16 million.

Other important sources of income in the WRPA are the wood products industry and the petroleum industry - particularly in the Louisiana portion. Most industries in the area process wood, petroleum, and agricultural products.

In 1968 the 53,700 persons employed in the WRPA had total earnings of $291 million (1967 dollars). Of this total earnings, 36 percent came from agriculture, forest, and fisheries, 12 percent from manufacturing, 15 percent from government, 13 percent from retail trade, 8 percent from services, and 16 percent from other sources.

Railroads and major Federal and State highways serve WRPA 6. Also, numerous State and local roads provide transportation routes into and from local areas of the WRPA. Additionally, a network of power and telephone lines and natural gas and petroleum distribution lines serve the area, while several water transportation facilities exist on the Mississippi River and Ouachita River systems.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in the WRPA occurs more often in the spring and winter months of the year, but can occur throughout the year. The elongated shape of the basins and the twisting and interconnected channels result in floods of relatively long duration. Some floods occur during the cropping season, resulting in delayed land preparation and planting of crops and in damages to crops and pastures. Improvements subject to flooding consist mostly of relatively low-type farm structures and local roads. In general, the railroads and principal highways are located above flood levels. Industry operations incur minor losses. Two general types of flooding occur as follows below.

Headwater Flooding

Land along various drainage arteries in the WRPA is subject to flooding from high stages resulting from runoff from the watersheds of tributary streams. Under extreme conditions, such as occurred in spring of 1958, headwater flooding from Bayou Bartholomew escaped eastward over the natural high banks of the bayou and aggravated the overflow conditions.

Local Flooding

Land in local areas of WRPA 6 where drainage patterns are poorly developed is subject to flooding from local excessive rainfall.

Major Historical Floods

General flooding throughout WRPA 6 has occurred frequently during the past, with varying damage levels. Brief descriptions of five significant floods follow.

1927 Flood

The flood of 1927 was the result of intense rains of long duration over the entire Mississippi River Basin from December 1926 through April 1927. A total of six levee crevasses occurred in the main line levees of the Arkansas and Mississippi Rivers bordering WRPA 6. As a result of the levee crevasses, most of the WRPA was inundated by flood waters causing flood damages estimated at $18 million.

1932 Flood

Heavy rains during the winter and early spring led to the floods of 1932. Average monthly rainfall of 13.6 inches in December of 1931, 12.0 inches in January of 1932, and 5.9 inches in February 1932 occurred over the WRPA drainage area. Overflow conditions at Girard, Delhi, and Tendal, Louisiana, extended from 17 December 1931 to 9 March 1932, a period of 84 days.

Floodwater south of Tallulah, Louisiana, May 1927.

1947 Flood

Heavy rains during the late fall and winter led to the floods of 1947. Monthly rainfall of over 7 inches for November 1946, over 11 inches for January 1947, and over 10 inches for April 1947 occurred at some stations in the WRPA.

1953 Flood

Heavy rains throughout the winter and spring of 1953 led to the floods of 1953. Monthly rainfall of 6 inches in December 1952, 8 inches in February 1953, 6 inches in March 1953, 9 inches in April 1953, and 15 inches in May 1953 were exceeded at some stations in the WRPA. Approximately 100,000 acres were flooded.

1958 Flood

The flood of 1958 is the flood of record on many streams in the WRPA. Two periods of intense rainfall occurred on 24-26 April and 28 April - 1 May. Also, smaller amounts of rainfall that prolonged the flood period occurred on 9, 18-20, 25, and 27-28 May. In addition, heavy rainfall in WRPA 5 caused Bayou Bartholomew floodwaters to escape eastward over the natural high banks of the bayou and further aggravated overflow conditions. Although two storm periods occurred, they happened so close together that the runoff pattern for most streams was similar to the pattern for a single storm.

Flooding began in the last week of February with some streams falling below flood stage about a week later. However, many streams remained in flood stage until early summer due to the continued heavy rainfall. Record discharges occurred on many streams, as the second storm period came while the streams were still rising from the first storm. Approximately 210,000 acres were flooded.

1973 Flood

During the fall of 1972, wet weather hampered harvesting operations causing eventual loss of some of the crop. The rains continued into the winter months with December totals double the observed normal and January totals well above normal. February totals were near normal but streams remained at high stages. Heavy rains resumed in March with the March 15-16 storm period producing totals varying from 3 to 5 inches in the southern part of the WRPA to over 7 inches in the northern part. During this storm period and shortly thereafter most of the streams of the area responded with their highest stages of the 1973 flood period. The rains continued into April, but the streams stayed below March levels.

Over 907,000 acres were flooded with almost 389,000 acres of this cleared land. Much of the estimated $28.4 million in damages was agricultural which accounted for about 85 percent of the total. Much of this was crop damage resulting from unharvested 1972 crops, planting of substitute crops due to the late planting season, or no planting at all in some areas. Damage to urban areas was also significant, being estimated at $3.3 million.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed flood control improvements that prevent damages from headwater, Mississippi River, Arkansas River, and Ouachita River floods. A summary of these improvements is shown below in table 35. The Inventory of Facilities Appendix contains detailed information on these improvements.

Lands in WRPA 6 receive essentially complete protection from floods of the major rivers bordering the area by the south bank Arkansas River levee and the west bank Mississippi River levee. Also, the east bank Ouachita River levee provides partial protection to the area.

Lands receiving additional protection in the Boeuf River Basin are located along the channels of the Boeuf River and their principal tributaries, Camp Bayou, Canal 18, Caney Bayou, Crooked Bayou, Fleschmans Bayou, and Garrett Bridge; Grady-Gould; and Randolph-Walnut Lake Watersheds. These channel improvements of the major streams and principal tributaries and in the nine watersheds are directed toward reducing damages that result from headwater flooding in the WRPA.

Lands receiving additional protection in the Tensas River Basin are located along the channels of the Tensas River and Bayou Macon and their principal tributaries and in the Arkansas City, Arkansas-Louisiana, Central Madison, Chicot, Kelsho-Rohwer, North Tensas, Redfork, South Tensas, Walnut-Roundaway, Wells Bayou, and West Madison watersheds. These channel improvements of the major streams and principal tributaries and in the 11 watersheds are also directed toward reducing damages that result from headwater flooding in the WRPA.

Channel improvements are the principal structural measures for protection from headwater floods in WRPA 6. Local interests have further provided flood protection through drainage improvements in the area, and generally provide maintenance for flood protection facilities.

Table 35 - Summary of Local Protection Projects, 1970, WRPA 6[1/]

Basin	Channel Improvement Miles
Boeuf River	746.3
Tensas River	1,289.4
Total	2,035.7

1/ Consists of projects in both upstream watersheds and principal reaches.

Land Treatment

Presently, 940,236 acres in the WRPA are adequately treated to reduce erosion and sedimentation and to assist in the reduction of surface runoff. This land treatment results not only from local, State, and Federal group efforts, but also from individual landowner's efforts. Table 36 shows acres with adequate treatment by basins.

Table 36 - Land Treatment, 1970, WRPA 6

Basin	Land Adequately Treated Acres (1,000's)
Boeuf River	441
Tensas River	499
Total	940

Flood Forecasting

River and Flood forecasts for the WRPA are provided for the Louisiana part by the NOAA Weather Service office at New Orleans, Louisiana, and for the Arkansas part by the NOAA Weather Service office at Little Rock, Arkansas. The WRPA is also under surveillance by the Weather Service office radar that effectively detects severe weather and excessive rainfall. The news media of the area have access to the NOAA Weather Wire Service, which distributes weather and river information.

Remaining Flood Problems

The remaining flood problems in WRPA 6 result from flooding caused by excessive rainfall in local areas and inundation of land by stream overflow (headwater flooding). Flooding occurs along the principal streams and major tributaries, and in most watersheds. Agricultural damages account for 92 percent of remaining flood damages in the WRPA and occur primarily from floods of low frequency. Damages also occur to urban and built-up areas and to public improvements. Urban damages were evaluated for only overbank flooding. The potential urban damage due to interior drainage is not known. Figure 17 shows urban and built-up areas in the WRPA with average annual flood damages exceeding $25,000.

Agricultural lands in the Boeuf River Basin are still subject to flood damages. The Boeuf River, its principal tributaries, and streams in most basin watersheds flood these agricultural lands. Urban flood damages in the basin are generally confined to Rayville, Louisiana, and Gould, Arkansas.

Generally, damages in the Tensas River Basin are the same types as described for the Boeuf River Basin. However, flood flows entering Lake Chicot have caused siltation and deterioration of the lake as a recreation area. If these flows continue, the lake's future as a recreation area is doubtful.

Table 37 shows the acres subject to flooding and average annual damages under the existing conditions. The data is shown for each principal basin and for the entire WRPA by principal streams and upstream watersheds. Total average annual flood damages in the WRPA amount to about $18 million.

In the presentation of damages, authorized projects that were initiated by the end of FY 1973 and have short construction periods are considered in place. Projects requiring a long, continuing construction period to provide a significant degree of protection were considered only as the completed portion of the project would affect flooding and damages at the end of FY 1973.

Table 37 - Remaining Flood Problems (1970), Existing Conditions - WRPA 6

Basin	Area Subject to Floods (1,000 Acres)		Average Annual Damages ($1,000) Damages Due to Flooding											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Boeuf River														
Headwater Flood	627	1,335	2,033	68	496	2,597	10,482	20	315	10,817	12,515	88	811	13,414
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tensas River														
Headwater Flood	406	1,090	761	0	178	939	3,372	1	267	3,640	4,133	1	445	4,579
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WRPA Total														
Headwater Flood	1,033	2,425	2,794	68	674	3,536	13,854	21	582	14,457	16,648	89	1,256	17,993
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total						3,536				14,457				17,993

FUTURE DAMAGES

General

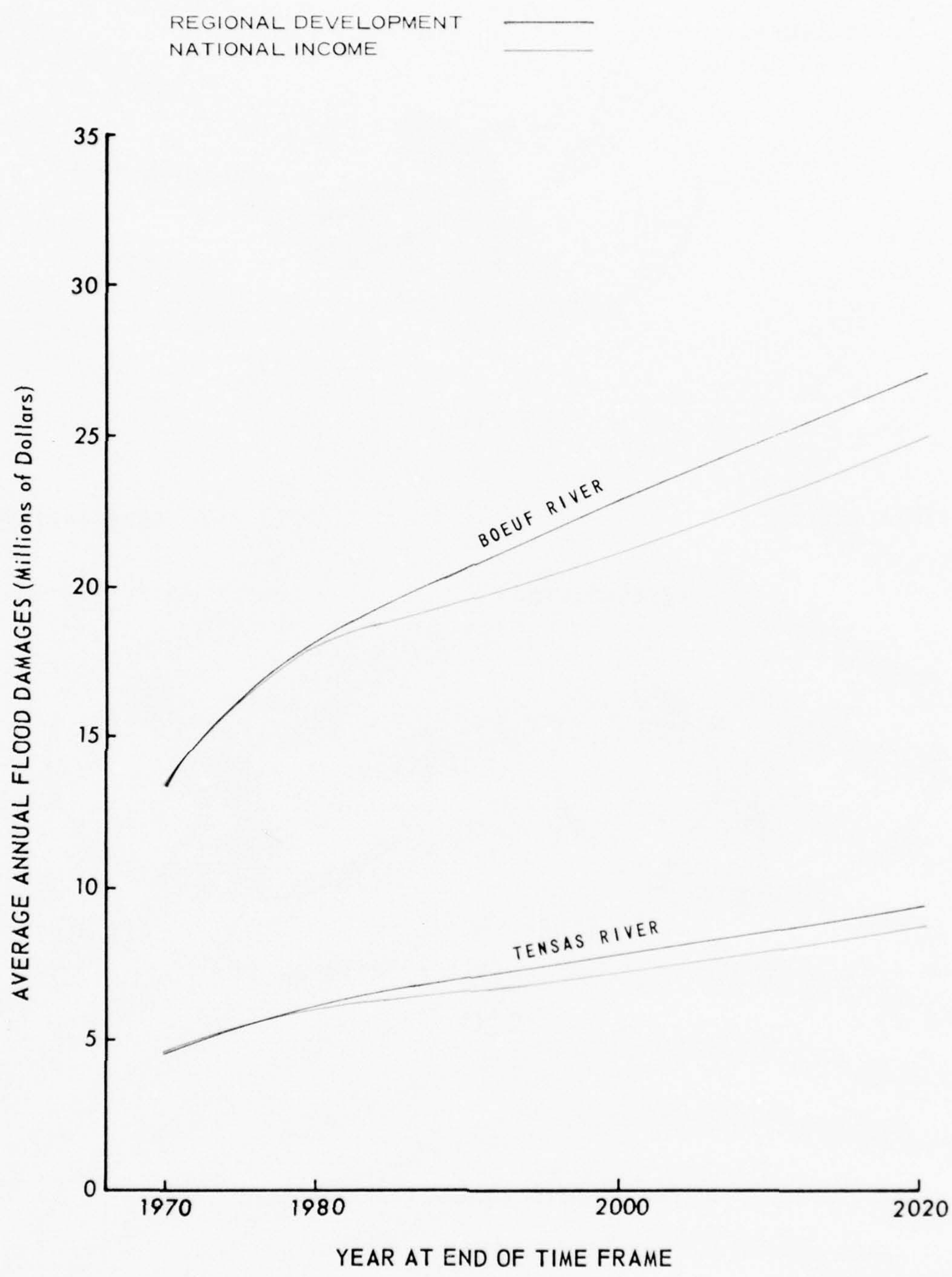
Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a slightly higher level of economic development that would improve the WRPA's industrial comparative advantage and more fully utilize the available resources of WRPA 6.

Future use of lands in the floodplains is expected to be about the same under both the National Income and Regional Development objectives. However, urban development is expected to be more dense, agricultural cropping patterns different, and crop yields slightly higher under the Regional Development objective as compared to the National Income objective.

Figure 18 illustrates the trends and relative magnitudes of future damages. The distribution of damages by basin for each of the two objectives is shown in figure 19 for the year 1970-2020.

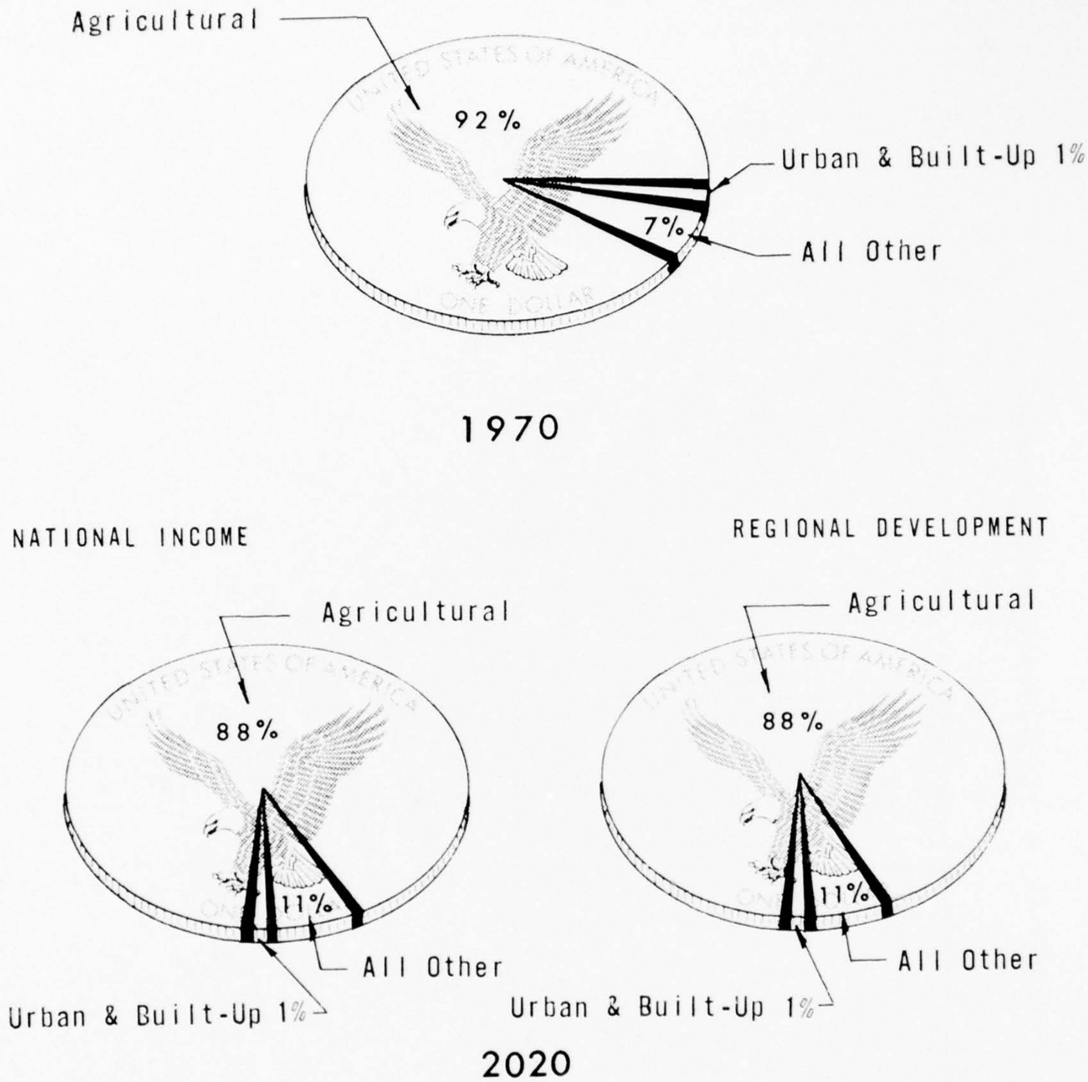
Future Flood Damages with National Income Growth Rate

Projected average annual flood damages for upstream watersheds and principal reaches by major basin under the National Income objective are provided in table 38.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-6

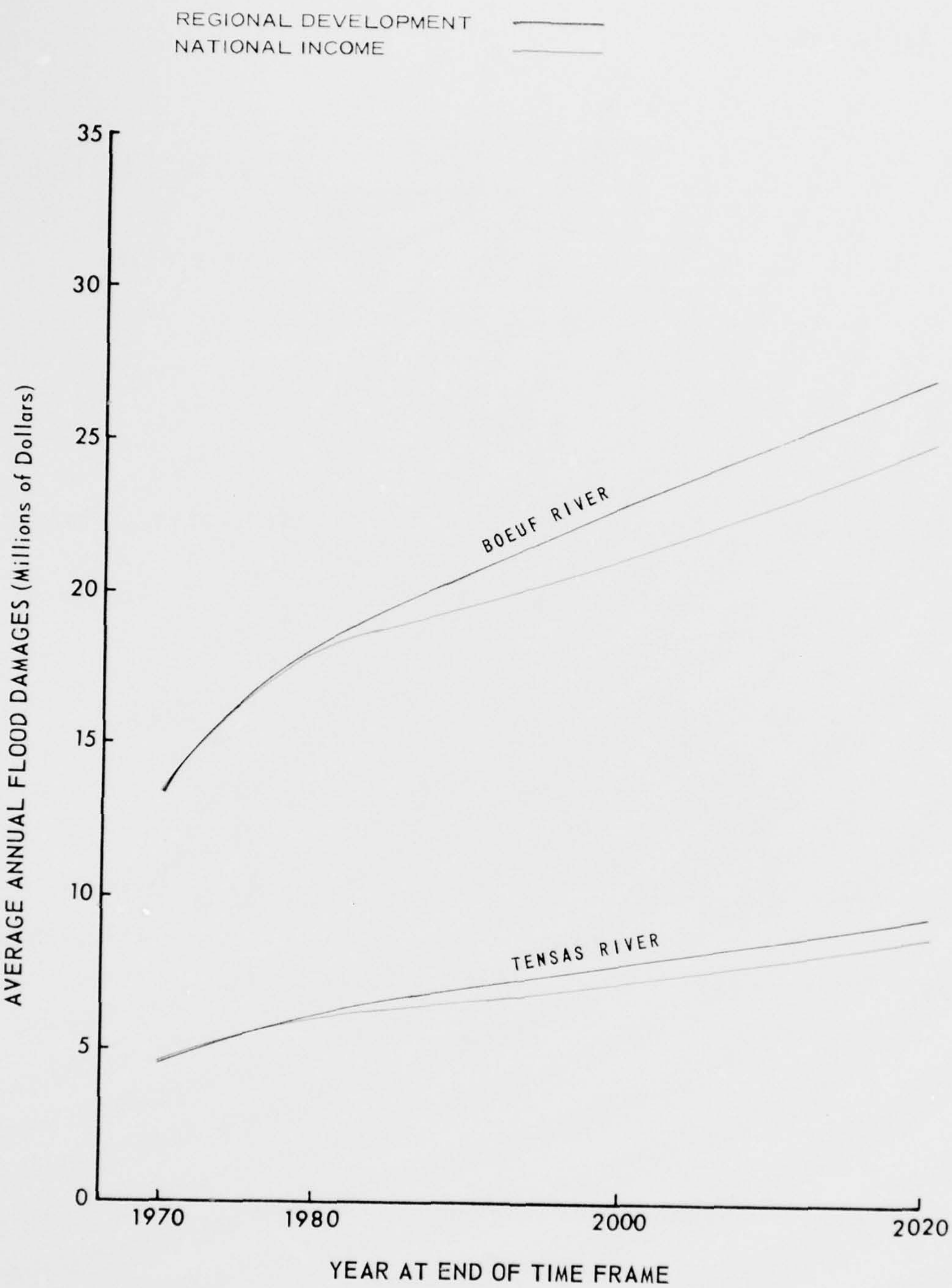
Figure 18



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-6

Figure 19



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-6

Figure 18

Table 38 - Projected Average Annual Flood Damages, National Income Growth, WRPA 6

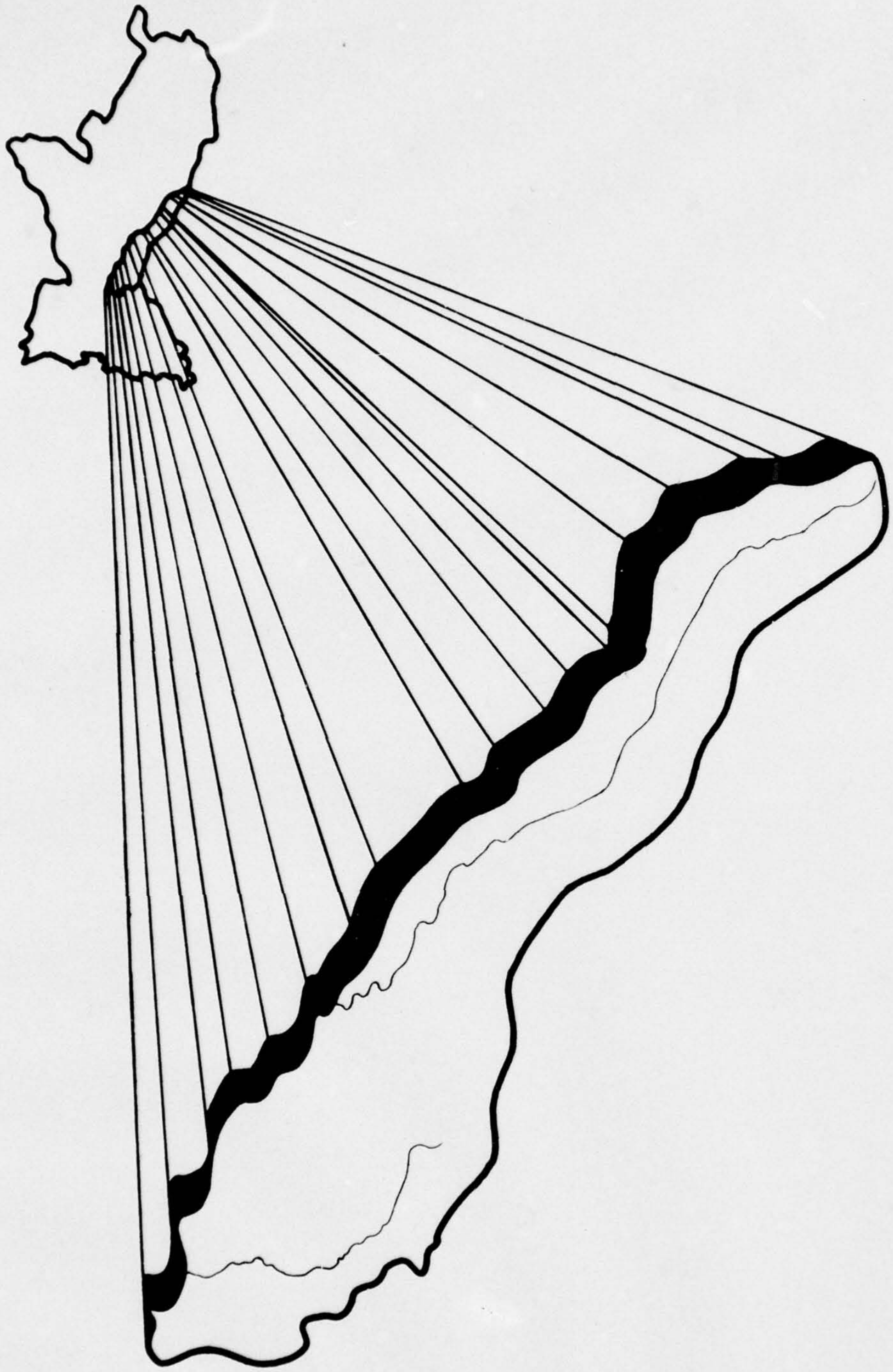
Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Boeuf River	Upstream Watersheds	10,818	14,962	17,862	21,405
	Principal Streams	2,597	3,283	3,493	3,647
	Total	13,415	18,245	21,355	25,052
Tensas River	Upstream Watersheds	3,639	5,018	6,163	7,700
	Principal Streams	939	1,074	1,118	1,119
	Total	4,578	6,092	7,281	8,819
WRPA TOTAL	Upstream Watersheds	14,457	19,980	24,025	29,105
	Principal Streams	3,536	4,357	4,611	4,766
	Total	17,993	24,337	28,636	33,871

Future Flood Damages with Regional Development Growth Rate

Projected average annual flood damages for WRPA 6 under the Regional Development growth rate are shown in table 39.

Table 39 - Projected Average Annual Flood Damages, Regional Development Growth, WRPA 6

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Boeuf River	Upstream Watersheds	10,818	14,973	19,305	23,235
	Principal Streams	2,597	3,438	3,855	4,018
	Total	13,415	18,411	23,160	27,253
Tensas River	Upstream Watersheds	3,639	5,026	6,666	8,342
	Principal Streams	939	1,121	1,232	1,254
	Total	4,578	6,147	7,898	9,596
WRPA TOTAL	Upstream Watersheds	14,457	19,999	25,971	31,577
	Principal Streams	3,536	4,559	5,087	5,272
	Total	17,993	24,558	31,058	36,849



WRPA 7

W R P A 7

DESCRIPTION

General

WRPA 7 covers an area of about 6,573 square miles located in central and southwest Mississippi (see figure 20). The WRPA is bounded on the west by the Mississippi River, on the northwest by the Yazoo River Basin, on the east by the Tombigbee River and Pearl River Basins, and on the south by the Amite River Basin and several small watersheds that drain directly into the Mississippi River.

Topography

The WRPA consists of two principal hydrologic areas. The Big Black River Basin comprises the northern part of the WRPA; the Homochitto-Bayou Pierre Area comprises the southern part. Figure 20 shows these two areas.

The Big Black River, with a drainage area of about 3,400 square miles, rises in the eastern part of Webster County, Mississippi, and flows about 270 miles in a southwest direction to its outlet into the Mississippi River 25 miles south of Vicksburg, Mississippi. The basin's length is about 155 miles, and its average width is 22 miles.

No single tributary of the Big Black River Basin controls any appreciable amount of the total drainage area. However, numerous small tributaries thoroughly dissect the basin and enter the main channel at fairly even intervals throughout its length. These tributaries, few of which exceed 20 miles in length, have their source in the hill section of the basin and carry a rapid runoff from drainage areas that vary from a minimum of about 6 to a maximum of about 200 square miles.

The terrain of the Big Black Basin consists primarily of upland or hill area except for some rolling prairie in Madison County and the alluvial area of the Mississippi River floodplain. The upper reaches of the basin have ridges with elevations above 600 feet 1/ and are dissected by numerous streams. The topography is gently sloping to steep with some wide ridge tops. The lower reaches, known as the Loess or Bluff Hills, have ridges that extend to an elevation of more than 300 feet. This lower area is well dissected by deep gorges. The topography is rolling to very steep with certain sections along the perimeter being rugged. The highest and most rugged terrain is found in the upper reaches of the eastern tributaries of the basin.

1/ All elevations refer to mean sea level unless otherwise specified.

Bottomlands of the Big Black Basin are nearly flat. The main valley elevations are about 350 feet near Eupora, 240 feet near Durant, 150 feet near Bentonia, and 75 feet near the outlet into the Mississippi River. The valley ranges in width from 1/2 mile to 3-1/2 miles from hill to hill, and has an average width of about 2 miles. The main valley bottomlands make up about 10 percent of the total basin drainage area. Total land subject to overflow makes up about 21 percent of the basin drainage area.

The Homochitto-Bayou Pierre Area with a drainage area of about 3,200 square miles is almost square in shape, with an average east-west dimension of about 54 miles and an average north-south dimension of about 60 miles.

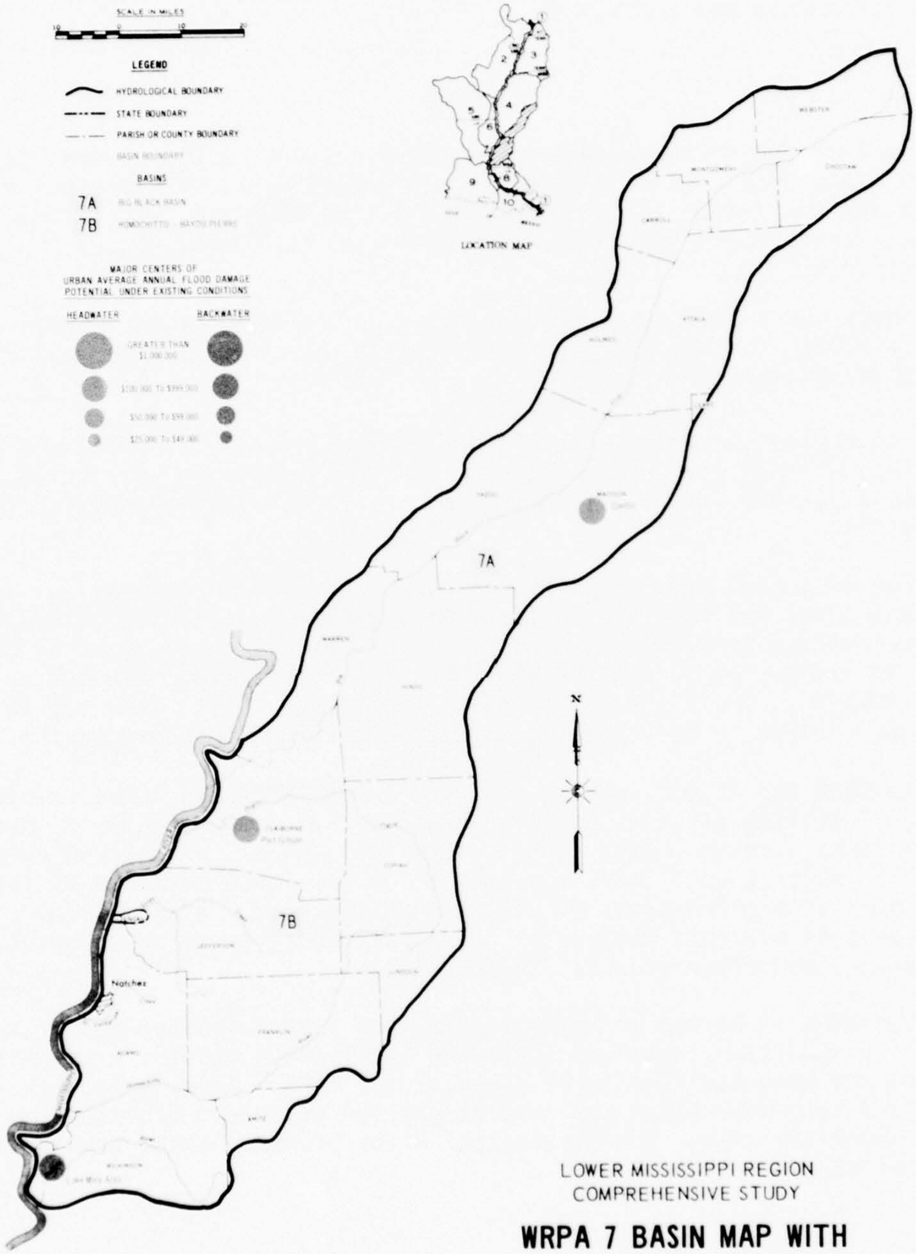
Three major streams - the Buffalo River, the Homochitto River, and Bayou Pierre - drain most of the basin and flow directly into the Mississippi River. Other tributaries that drain into the Mississippi River are Washout Bayou, St. Catherine Creek, Coles Creek, and Dowd Creek.

The terrain of the Homochitto-Bayou Pierre Area, located in southwest Mississippi, consists primarily of upland or hill area and Mississippi Valley alluvial area. The topography of the hill area, known as "Loess Hills," is rugged and steep to very steep, with narrow ridge tops. Elevations along the eastern and southern perimeter of the basin exceed 400 feet and extend to more than 460 feet in places. Near the alluvial flat lands the hill elevations extend to heights of about 300 feet. The alluvial area, interlaced with swampland, lakes, and agricultural lands, extends along the Mississippi River east bank and is very flat. Elevations range from 50 to 70 feet.

Climate

The huge land area to the north, the Gulf of Mexico to the south, and the subtropical latitude all influence the climate of WRPA 7. In the spring and summer months, the prevailing southerly winds provide a moist, semitropical climate favorable for afternoon thundershowers. In the fall and winter months, the area is alternately subjected to warm tropical air from the Gulf of Mexico and cold continental air from the north. Also, tropical storms or hurricanes cross the area occasionally with resulting wind and flood damage.

The average annual temperature is 65° F. The average monthly temperatures range from 50° F. in the winter to 80° F. in the summer. Winter temperatures below zero and sustained periods of subfreezing weather are uncommon. The growing season or frost-free period averages 7 to 8 months.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 7 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 20

Rainfall throughout the area averages 52 inches annually. Monthly rainfall averages range from 2.1 inches in October to 5.6 inches in March, with the period from November to May incurring an average of about 5.0 inches per month.

Economy

In 1970 the WRPA population was about 156,000, a 5.3 percent decrease since 1959. Of this total population, 29 percent was urban and 71 percent was rural. Principal cities in the WRPA are Natchez and Canton, Mississippi, with 1970 populations of 19,704 and 10,503, respectively.

There was a loss of 34,000 persons from the WRPA in the period from 1940 to 1970. In 1940 the population in the area was 190,000, about 22 percent greater than in 1970.

Per capita income for WRPA 7, increasing steadily, remains lower than the National per capita income. In 1968 the area's per capita income was $1,896, or 57 percent of the per capita income reported for the Nation.

The WRPA has suffered as the result of decreasing demands for agricultural labor and from a slow industrial growth. Agriculture, including pasture and forest land, always a major part of the economy of the area, uses about 94 percent of the land. Principal crops are cotton, corn, soybeans, small grains, pasture, and timber. Most industry in the area relates to agriculture, wood products, and food processing.

In 1968 the 58,000 persons employed in the WRPA had total earnings of $245.7 million (1967 dollars). Manufacturing accounted for 33 percent of the total earnings, with lumber, furniture, paper, and allied products being the major industries. The balance of the total earnings of the WRPA comes from government, 15 percent; agriculture, forestry, and fisheries, 14 percent; wholesale and retail trade, 14 percent; services, 11 percent; and other sources, 13 percent.

The WRPA is served by major Federal and State highways and by railroads. In addition, numerous State and local roads provide transportation routes into and from local areas of the WRPA. Also, a network of power and telephone lines and natural gas and petroleum distribution lines serve the area. The Mississippi River provides water transportation for WRPA 7.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in WRPA 7 occurs more often in the winter and spring months of the year. However, floods occur throughout the year. When the floods occur during the cropping season, the results are delayed land preparation and planting of crops and damages to crops and pastures. Also, damages in the predominantly agricultural floodplain occur to roads, bridges, farm buildings, urban areas, and built-up rural areas.

Flood durations range from a few hours to periods of about 2 days in most tributary streams. Along the principal streams flood durations are longer, especially in the lower reaches. Some of the tributary streams have high peak flows for their small drainage areas because of the steep topography. Two major types of flooding generally occur as described below.

Backwater Flooding

Land in the lower reaches of the principal streams is subject to flooding from the backwaters of the Mississippi River.

Headwater Flooding

Land along most drainage arteries in the WRPA is subject to flooding from high stages on those streams resulting from runoff within their watersheds.

Major Historical Floods

Large floods in the Big Black River occur with about a 5-year frequency. Since a flood of any size inundates much of the bottomland, large floods cause little more damage than floods of lower frequency. For example, the estimated 25-year-frequency flood of 1930 caused about the same damage as a 4-year-frequency flood.

Major floods in the Big Black Basin occurred in 1927, 1930, 1937, 1944, 1946, 1949, 1951, 1958, 1961, and 1973. Several of the recent floods are described below.

1951 Flood

Heavy rainfall during the period 27 March-19 April 1951 occurred over the WRPA. Vaiden, Mississippi, recorded 12.6 inches of rainfall; Germania, Mississippi, recorded 13.5 inches. Average storm rainfall over the area ranged from 5 to 13 inches. The storm produced maximum record stages at all main stream gaging stations except at Bovina, located in the lower portion of the basin.

1958 Flood

Storm rainfall occurring during the period 24 April-6 May 1958 produced the 1958 flood. Vaiden, Mississippi, measured 11.0 inches of rainfall; Canton, Mississippi, measured 10.8 inches.

1961 Flood

Storm rainfall averaging more than 10 inches over the drainage basin fell druing the period 4-18 December 1961. Measured amounts were 12.4 inches at Canton, Mississippi, and 13.9 inches at Germania, Mississippi. The storm produced the maximum stage of record at Bovina, Mississippi.

Floods occur at frequent intervals in the Homochitto-Bayou Pierre Basin. These floods may only occur in one or two of the principal tributary streams of the basin depending on the rainfall distribution. Maximum discharges and stages were produced at most stations in the storm described below.

1964 Flood

The heavy rainfall that caused this flood resulted from Hurricane Hilda. Most of the rainfall fell on 3-4 October 1964. Rainfall at most stations in the basin exceeded 10 inches, with most falling on 4 October.

1973 Flood

Heavy rains in the latter part of 1972 and the first quarter of 1973 resulted in the flooding of 212,310 acres in WRPA 7. Twenty-eight percent (59,860 acres) of the area flooded was cleared land. Urban areas represented less than 1 percent of the total area flooded.

The heavy rains began in the Big Black Basin during December 1972 and kept the river above flood stage the entire month. Brief rises were experienced during February due to additional rain. Heavy rainfall occurred throughout the month of March with the heaviest storms occurring on the 15th and 16th with amounts varying from 2 inches in the lower part of the basin to over 7 inches in the upper part. Record stages were recorded at some locations during the month. Rainfall during April and May produced flooding in some reaches but stages were well below the March levels.

Rainfall from December 1972 to February 1973 did not produce unusually high stages in the Homochitto and Buffalo River Basins. Rainfall was heavy throughout March with the most significant storms observed on 24-25 March when amounts varying from 3 to 7 inches were recorded. Both the Homochitto and Buffalo Rivers responded with sharp rises and maximum crests for the 1973 flood period. Rainfall during April and May kept the streams at high levels but usually below bankfull.

The flooding in WRPA 7 resulted in considerable damage to agricul-

tural operations (crops, farm buildings and equipment, farm roads, fences, drainage systems, etc., and livestock losses). Some 1972 crops were lost due to the wet fields and farmers were unable to prepare land and plant crops at the proper time for the 1973 season. Total agricultural damages were about \$4.7 million.

Flood waters also resulted in a significant amount of damage to public roads, bridges, and railroads; losses due to rerouting of traffic; costs from evacuation of persons and property; and some damage to urban properties. Total damage for these categories amounted to almost \$1 million.

Flooded cotton field, Big Black River Basin, Mississippi.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed flood control improvements in WRPA 7 that prevent damage from headwater flooding along some principal streams and tributaries. Also, the Natchez Port area receives protection from Mississippi River flooding. Table 40 and 41 below summarize these improvements. The Inventroy of Facilities Appendix contains detailed information on the projects.

Lands receiving protection from flooding in the Big Black River Basin are located along the main Big Black channel and several tributaries located in Attala, Carroll, Montgomery, Choctaw, and Webster Counties. Some flood control work on the Big Black was completed in 1939; tributary work was completed in 1941; however, these projects have not been maintained and have lost some of their effectiveness. In addition, watersheds receiving flood protection are Bentonia Creek, Box Creek, Ellison Creek, Five Creeks, Long Creek, Mulberry Creek, Panther Creek, Persimmon and Burnt Corn Creeks, and Tackett Creek. All of the project measures along the principal streams, tributaries, and in the watersheds reduce flood damages that result from headwater flooding in the Big Black Basin.

The flood prevention improvments are limited in the Homochitto-Bayou Pierre Basin. Authorized work on the lower 35 miles of Homochitto River was completed in 1952. Authorized work on the Buffalo River has been deferred indefinitely. Improvements in the Second Creek and the Tallahalla Creek watersheds provide flood protection in these tributaries. The project measures are directed toward reducing flood damages from headwater flooding in the basin.

Principal flood control structural measures in WRPA 7 include levees, channel improvements, and floodwater retarding dams. Local interests have provided some additional flood prevention measures without Federal assistance. In addition, local interests generally provide maintenance for flood protection facilities in the WRPA.

Table 40 - Flood Control Storage, 1970, WRPA 7

Basin	Major Reservoir	Small Reservoir	Totals
	Flood Control - Storage in 1,000 Acre-Feet		
Big Black River	-	37.3	37.3
Homochitto-Bayou Pierre	-	24.9	24.9
Total	-	62.2	62.2

Table 41 - Summary of Local Protection Projects, 1970, WRPA 7 1/

Basin	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Big Black River	-	485.3	-	-
Homochitto-Bayou Pierre	0.8	41.1	1	100
Total	0.8	526.4	1	100

1/ Consists of projects in both upstream watersheds and principal reaches.

Land Treatment

Presently, 1,324,824 acres of land in WRPA 7 are adequately treated to reduce erosion and sedimentation and to assist in the reduction of surface runoff. This land treatment results not only from local, State, and Federal group efforts, but also from individual landowner's efforts. Table 42 shows by basin the acres with adequate treatment.

Table 42 - Land Treatment, 1970, WRPA 7

Basin	Lands Adequately Treated Acres (1,000's)
Big Black River	684
Homochitto-Bayou Pierre	641
Total	1,325

Flood Plain Information

In 1969 a floodplain information report presenting the local flood situation in Natchez, Mississippi, was completed.

Flood Forecasting

River and flood forecasts for the WRPA are provided by the NOAA Weather Service office at Jackson, Mississippi. The WRPA is also under surveillance by the NOAA Weather radar located at Jackson, Mississippi. The news media of the WRPA have access to the NOAA Weather Wire Service, which distributes weather and river information.

Emergency Operations

When natural disasters have occurred in the WRPA, local State, and Federal agencies have cooperated in emergency operations. These past operations have included evacuation and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and in recovery operations.

Remaining Flood Problems

The remaining flood problems in WRPA 7 result from headwater flooding along the principal streams, the principal tributaries, and in most watersheds of the WRPA. In addition, backwater flooding of the Mississippi River causes flood damages in the southern part of the WRPA. This flooding in the WRPA causes damage to crops, pasture, farm buildings, fences, other farm improvements, local roads and bridges, and urban and built-up areas.

While headwater flooding causes substantial flood damages in certain urban areas, other sources of flood problems exist in these urban areas. Inadequate storm sewers and drainage outlets can cause severe flooding problems while adjacent streams are still within banks. However, data pertaining to these problems are not available, and evaluation of the extent of the problems was not possible.

Floods and resulting damages occur within the Big Black Basin along the Big Black River, its principal tributaries, and in all watersheds. Headwater flooding along the main stem occurs about twice a year during the crop-growing season. However, severe floods have been recorded for all months of the year. Flooding in the upstream watersheds in the upper and central parts of the basin is more severe than in the lower part of the basin. Urban flood damages are prevalent in Canton, Mississippi. Figure 20 shows the location of areas receiving urban and built-up flood damages exceeding $25,000 annually.

Flood damages in the Homochitto-Bayou Pierre Basin occur along the principal streams, tributaries, and in most watersheds in the basin. Crops, pastures, farm improvements, and local roads are damaged. In addition, major floods that usually result in high peak flows and stages have damaged major road bridges. Mississippi River backwater flooding occurs in several areas with the most noticeable flooding resulting in agricultural damages to an area just south of Natchez, Mississippi, and damage to the built-up area at Lake Mary. Also, Port Gibson, Mississippi, has major average annual flood damages.

Table 43 shows the acres subject to flooding and average annual flood damages under the existing conditions. The data are shown for each principal basin and for WRPA 7 by principal streams and upstream watersheds. Total average annual flood damages in the WRPA amount to $5,456,000.

Table 43 - Remaining Flood Problems, Existing Conditions, WRPA 7

Basin	Area Subject to Floods (1,000 Acres)		Average Annual Damages Due to Flooding ($1,000)											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Big Black														
Headwater Flood	220	291	199	916	119	1,234	1,789	0	404	2,193	1,988	916	523	3,427
Backwater Flood	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Homochitto-Bayou Pierre														
Headwater Flood	70	196	243	175	31	449	638	13	306	957	881	188	337	1,406
Backwater Flood	81	-	239	118	266	623	-	-	-	-	239	118	266	623
WRPA Total														
Headwater Flood	290	487	442	1,091	150	1,683	2,427	13	710	3,150	2,869	1,104	860	4,833
Backwater Flood	81	-	239	118	266	623	-	-	-	-	239	118	266	623
Totals						2,306				3,150				5,456

FUTURE DAMAGES

General

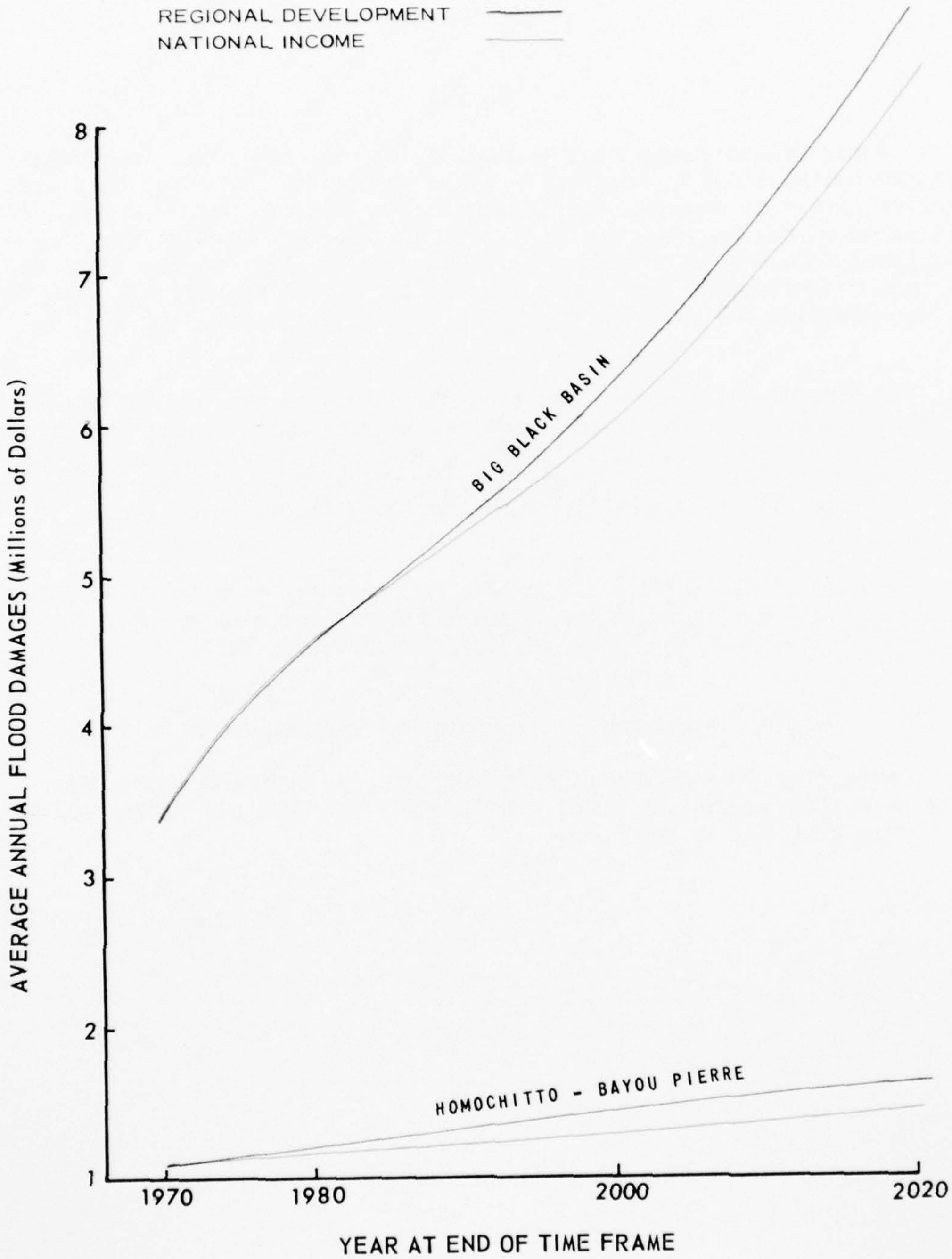
Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a slightly higher level of economic development that would improve the WRPA's industrial comparative advantage and more fully use the available resources of WRPA 7.

Future use of lands in the floodplains are expected to be about the same under both the National Income and Regional Development objectives. However, development is expected to be more dense, agricultural cropping patterns different, and crop yields slightly higher under the Regional Development objective than under the National Income objective.

Figure 21 illustrates the trends and relative magnitudes of future damages. The distribution by kinds of damages for each of the two objectives is shown in figure 22 for the years 1970-2020.

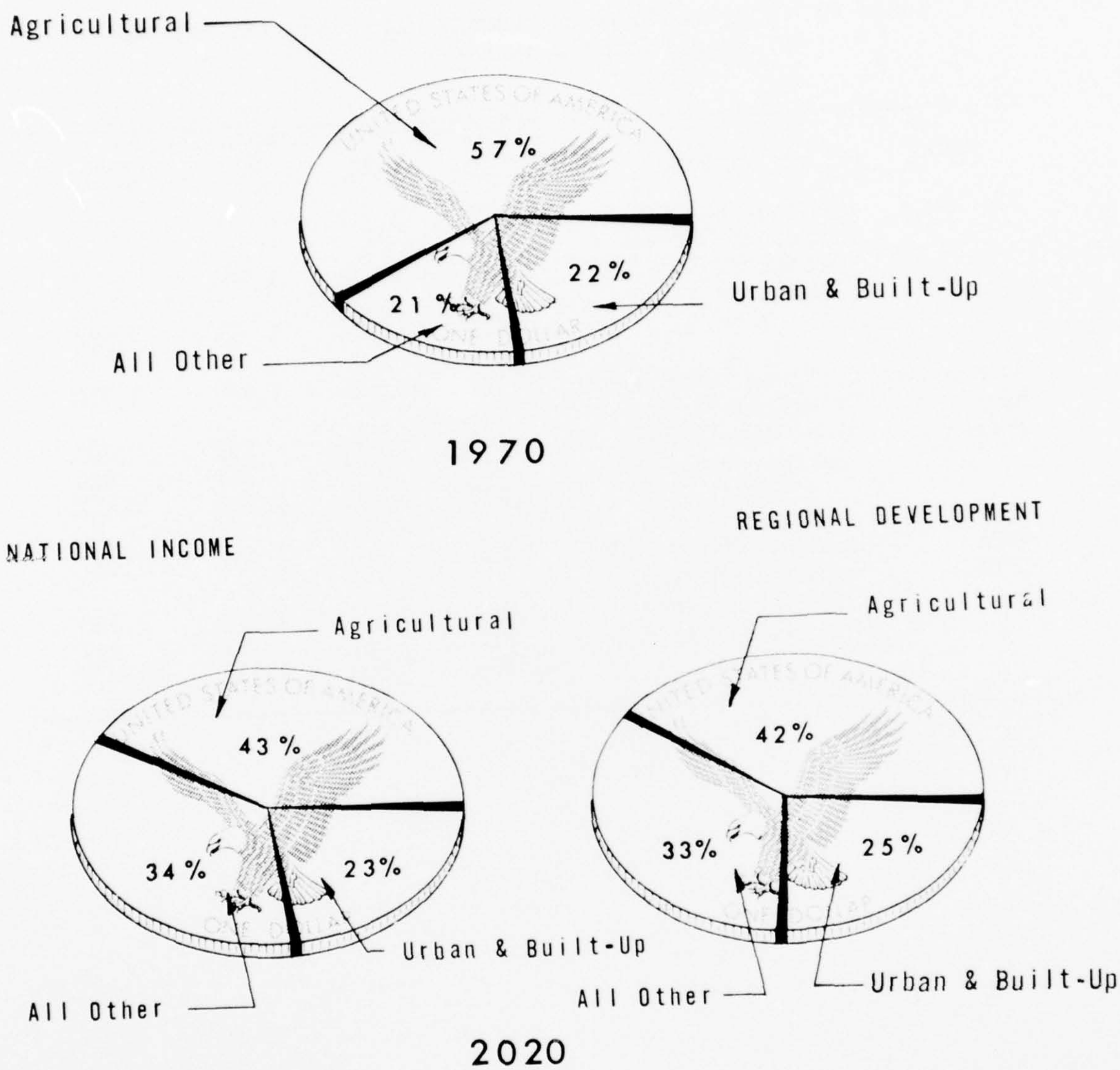
Future Flood Damages with National Income Growth Rate

Projected average annual flood damages for upstream watersheds and principal reaches by major basins under the National Income objective are provided in table 44.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-7

Figure 21



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-7

Figure 22

Table 44 - Projected Average Annual Flood Damages, National Income Growth, WRPA 7

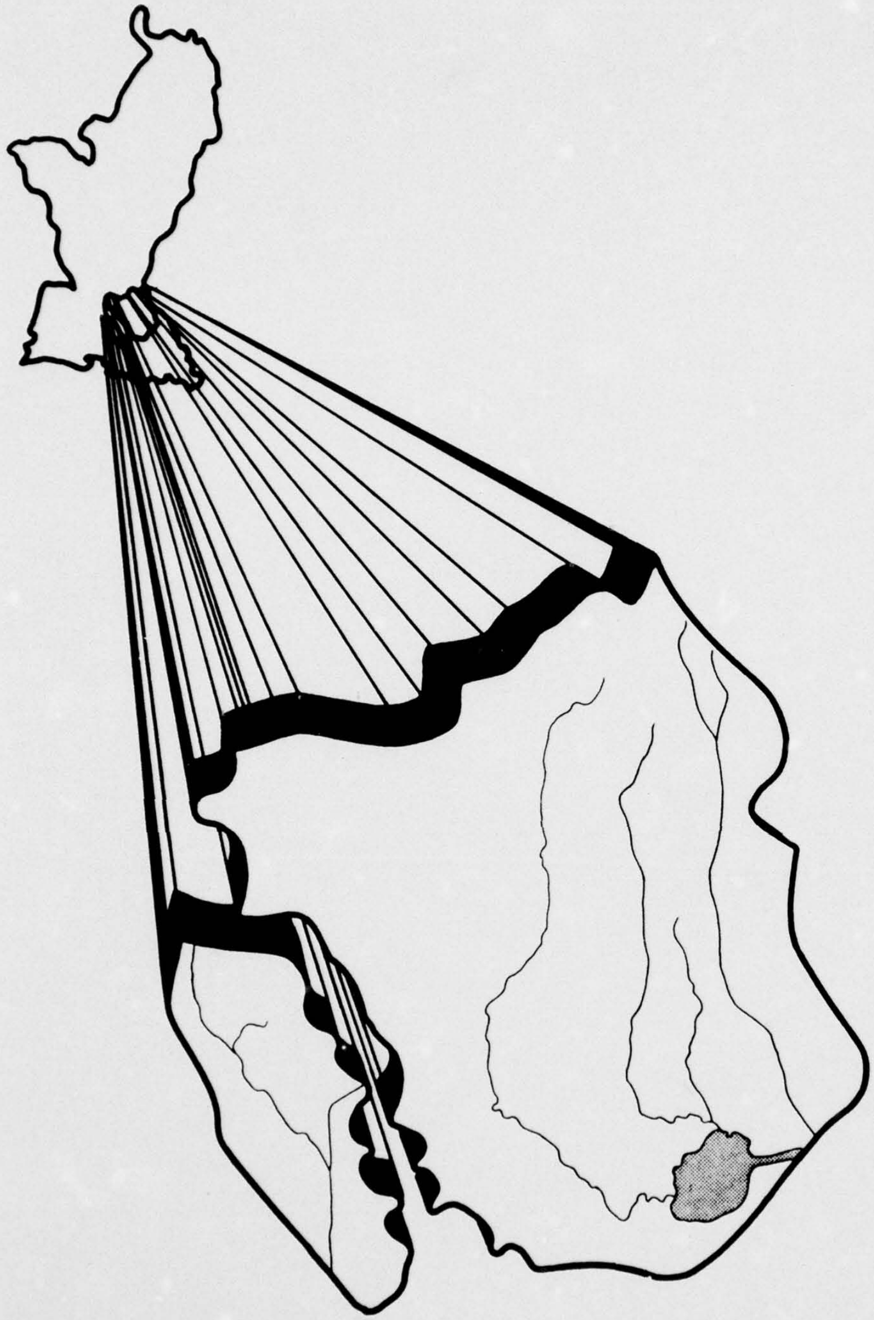
Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Big Black	Upstream Watersheds	2,193	3,214	4,036	5,272
	Principal Streams				
	Headwater Flood	1,234	1,372	1,944	2,992
	Backwater Flood	0	0	0	0
	Total	3,427	4,586	5,980	8,264
Homochitto-Bayou Pierre	Upstream Watersheds	957	1,377	1,886	2,710
	Principal Streams				
	Headwater Flood	449	473	532	603
	Backwater Flood	623	657	751	849
	Total	2,029	2,507	3,169	4,162
WRPA TOTAL	Upstream Watersheds	3,150	4,591	5,922	7,982
	Principal Streams				
	Headwater Flood	1,683	1,845	2,476	3,595
	Backwater Flood	623	657	751	849
	Total	5,456	7,093	9,149	12,426

Future Flood Damages with Regional Development Growth Rate

The projected average annual flood damages for WRPA 7 under the Regional Development growth rate are shown in table 45.

Table 45 - Projected Average Annual Flood Damages, Regional Development Growth, WRPA 7

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Big Black	Upstream Watersheds	2,193	3,214	4,088	5,372
	Principal Streams				
	Headwater Flood	1,234	1,457	2,188	3,417
	Backwater Flood	0	0	0	0
	Total	3,427	4,671	6,276	8,789
Homochitto-Bayou Pierre	Upstream Watersheds	957	1,377	1,904	2,752
	Principal Streams				
	Headwater Flood	449	488	586	667
	Backwater Flood	623	686	835	949
	Total	2,029	2,551	3,325	4,368
WRPA TOTAL	Upstream Watersheds	3,150	4,591	5,992	8,124
	Principal Streams				
	Headwater Flood	1,683	1,945	2,774	4,084
	Backwater Flood	623	686	835	949
	Total	5,456	7,222	9,601	13,157



W R P A 8

W R P A 8

DESCRIPTION

General

WRPA 8 encompasses an area of 5,705 square miles in southeastern Louisiana and southwestern Mississippi. The WRPA is divided by the Mississippi River into two parts. Approximately 4,912 square miles are located east of the Mississippi River, and 793 square miles are in the area west of the river (see figure 23). The area east of the river is bounded on the north by the Buffalo River and Homochitto River watersheds, on the east by the Pearl River and Chefuncte River watersheds, and on the south and west by the east bank of the Mississippi River between the latitudes of Fort Adams, Mississippi, and Laplace, Louisiana. The area west of the Mississippi River lies between the latitudes of Morganza, Louisiana, and White Castle, Louisiana, and is bounded by the west bank Mississippi River levee on the east and the East Atchafalaya Basin protection levee on the west.

Topography

The terrain east of the Mississippi River consists of rolling hill lands and alluvial lowlands with a fringe of tidal marsh at the shorelines of Lakes Maurepas and Pontchartrain. In the hill lands, elevations vary from about 50 feet 1/ at the latitude of Baton Rouge to about 500 feet northwest of McComb, Mississippi. Here the landscape is largely covered by pine forests and the streams are confined in well-defined valleys. The alluvial lowlands are south of the hills and extend from the latitude of Baton Rouge to the shores of Lakes Pontchartrain and Maurepas. Within the lowlands, tidal marshes and swamps are located along the lakes' perimeters and adjacent to the streams.

The area east of the Mississippi River that drains into Lakes Maurepas and Pontchartrain is referred to as the Pontchartrain Basin. Other areas that drain into the Mississippi River are referred to as part of the Mississippi River Basin. These basins are shown on figure 23.

The Pontchartrain Basin comprises an area of 4,169 square miles. Major streams in the Pontchartrain Basin are the Amite, Tickfaw, Natalbany, and Tangipahoa Rivers, which are tributary to the shallow tidal basins of Lakes Maurepas and Pontchartrain. Amite River rises in

---

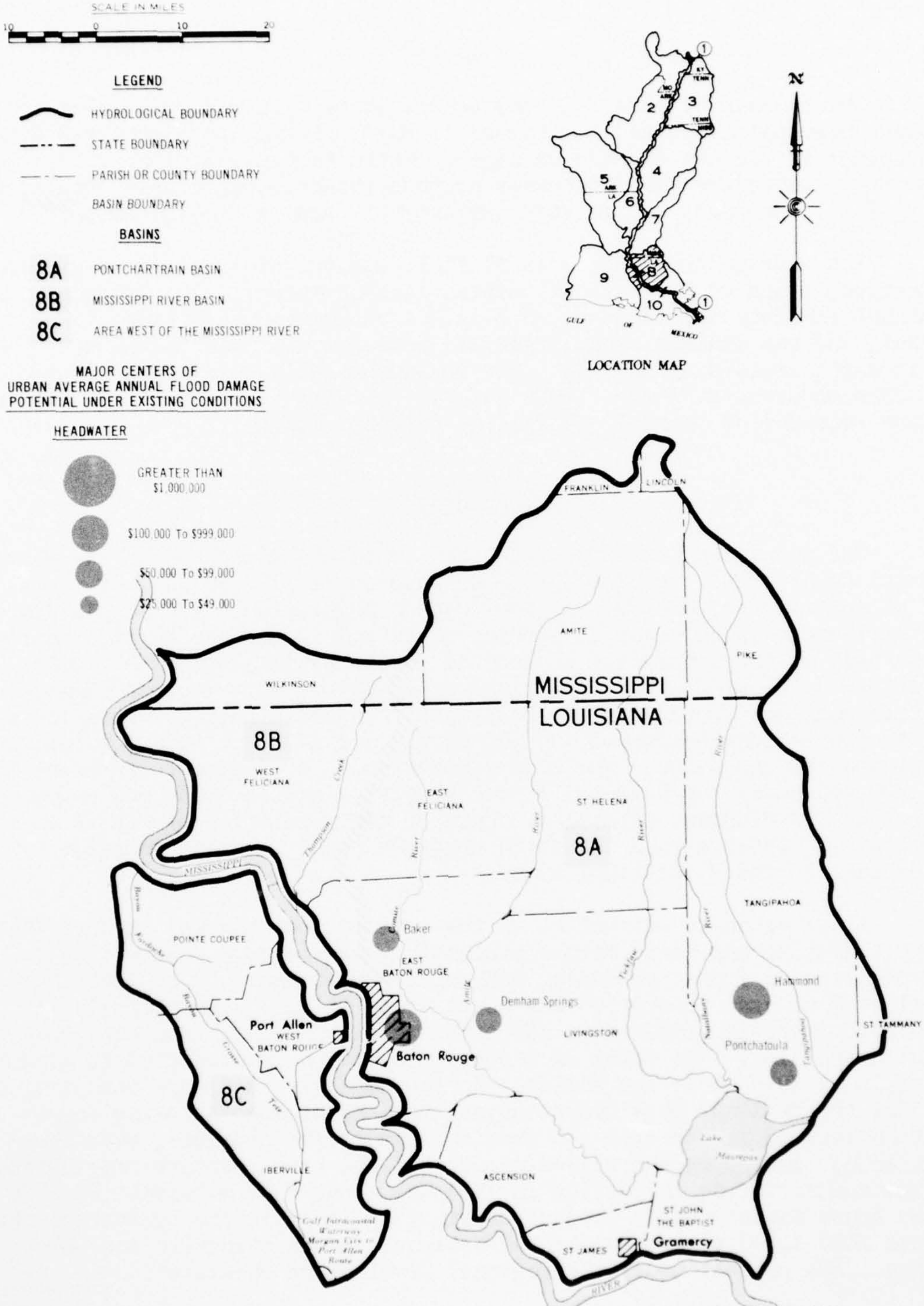
1/ All elevations refer to mean sea level unless otherwise specified.

the hills of southwestern Mississippi and flows in a south and southeasterly direction, a distance of 170 miles through pine-covered hills and timbered swamp, to the western side of Lake Maurepas. At mile 25.3 of the river, a control weir and 150-foot wide diversion channel to Lake Maurepas has been constructed to enhance runoff in the area. Principal tributaries of Amite River include Bayou Manchac and Comite River. The Tickfaw River, located east of the Amite River, rises in southwestern Mississippi southwest of McComb, flows in a southerly direction about 100 miles, and enters the northern end of Lake Maurepas. It is joined by the Natalbany River at about mile 2 and by the Blood River at about mile 7.5. The Tangipahoa River, located east of the Tickfaw River, rises in southwestern Mississippi near McComb, flows in a southerly direction about 110 miles, and enters Lake Pontchartrain on the north shore near the western end of the lake.

Bayou Sara and Thompson Creek, two left-bank tributaries of the Mississippi River, are in the Mississippi River Basin. Bayou Sara and Thompson Creek rise in the hills of southwestern Mississippi and flow in a south and southwesterly direction, a distance of 28 miles and 32 miles, respectively, to the Mississippi River.

The terrain in the area west of the Mississippi River consists solely of alluvial lowlands. The land is relatively low-lying and flat, with ground elevations varying from 50 feet in the north to 15 feet in the south. The higher elevations are located along the alluvial ridge adjacent to the Mississippi River. Flow in streams is usually sluggish and large areas of poorly drained land are evident.

Major drainage outlets in the area west of the Mississippi River are Choctaw Bayou, Bayou Grosse Tete, and the east Atchafalaya Basin protection levee borrow pit. Choctaw Bayou is formed by the confluence of Bayou Chaplin and Stumpy Bayou about 12 miles west of Port Allen, Louisiana. The bayou flows generally southeastward for about 7.5 miles and enters the Morgan City-Port Allen Route of the Gulf Intracoastal Waterway. Bayou Grosse Tete originates in Pointe Coupee Parish northwest of Erwinville, Louisiana, and flows northwesterly initially, then gently arches to the southeast and enters the Morgan City-Port Allen Route of the Gulf Intracoastal Waterway. Bayou Grosse Tete, which is about 40 miles in length, is connected with Choctaw Bayou by Bayou Cholpe, a tributary of Bayou Chaplin. The east Atchafalaya Basin protection levee borrow pit is a man-made channel along the eastern side of the protection levee. The borrow pit originates near the junction of the Morganza Floodway lower guide levee and the west bank Mississippi River levee, follows a southwesterly course initially, then turns southward and joins the Lower Grand River near Bayou Sorrel Lock.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 8 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 23

Climate

The climate of WRPA 8 is characterized by mild winters, relatively heavy precipitation, and hot summers. Major storms are associated with tropical hurricanes and the passage of extra-tropical cyclones. In summer, convective thundershowers produce intense, but highly localized, rainfall. Snowfall occurs very infrequently and in limited amounts.

The average temperature is 67.7° F. and the average annual precipitation, based on 30 years of record, is 57.9 inches. The maximum annual rainfall recorded was 93.2 inches at Hammond, Louisiana, in 1961, and the minimum annual rainfall recorded was 35.3 inches at Cinclare, Louisiana, in 1924. The maximum monthly rainfall of 21.0 inches occurred at Amite, Louisiana, in February 1961. Several stations have recorded no rainfall in various calendar months.

Economy

The population in 1970 of the ten Louisiana parishes and one Mississippi county that comprise WRPA 8 was approximately 547,000, or about 9 percent of the Lower Mississippi Region population. The population distribution in 1970 was 58 percent urban and 42 percent rural. Nearly one-half of the population is located in the Baton Rouge SMSA. Other cities in the area with populations of 10,000 or more include Hammond, Louisiana, and Scotlandville, Louisiana. In addition, there are 13 towns with populations between 2,500 and 10,000 and 20 towns with populations between 500 and 2,500. The 2020 population is projected to increase to 1,000,000 under the National Income objective and to 1,139,000 under the Regional Development objective. Much of the population growth is expected to center around the Baton Rouge SMSA and in areas immediately adjacent to the Mississippi River.

Major economic activities in the area include mineral production, petrochemical and basic metals processing, agriculture, harvesting and processing of forest products, and waterborne commerce. In 1969 the value of mineral production was about \$126 million. Commercially important minerals produced in the area are oil and gas, sand and gravel, salt, and lime. The value of mineral production is projected to almost triple by 2020 under the National Income objective and more than triple under the Regional Development objective. Major manufacturing industries located in the area are chemical and allied products, petroleum refining, and paper and allied products. The gross product originating from manufacturing industries in 1968 was about \$532 million. By 2020 the gross manufacturing product originating is projected to increase by more than 1,100 percent under the National Income objective and more than 1,300 percent under the Regional Development objective.

Agriculture also plays an important role in the economy. Much of the agricultural land is in pasture and used for the growing of livestock. Crop production plays a lesser role in the overall agricultural economy. Crops cultivated include sugarcane, corn, strawberries, rice, and soybeans. In the future, agricultural production will remain a major factor in the area's economy, with the value of production sold more than doubling by 2020 under either objective.

Land use in the planning area, a total of 3.7 million acres, consists of cropland, 9 percent; pasture, 10 percent; forest-woodland, 62 percent; urban and built-up land, 5 percent; water areas, 3 percent; and other land, about 11 percent. Projected land use under both objectives forecasts increases by 2020 of 20 percent in pasture and 52 percent in urban and built-up lands. Decreases are projected in the cropland and forest-woodland categories.

Land transportation is provided by three interstate highways, three Federal highways, numerous State and local roads, and four railways. There are numerous navigable waterways that serve the area, including the Amite River, Bayou Grosse Tete, Bayou Manchac, Blood River, Morgan City-Port Allen Route of the Gulf Intracoastal Waterway, Natalbany River, Tickfaw River, and the Mississippi River. The port of Baton Rouge, seventh largest in the Nation and third largest on the Gulf Coast, is at the head of deep-draft navigation on the Mississippi River. It deals heavily in petroleum, food grains, petrochemicals, and primary metal shipments.

Mississippi River flooding through levee crevasse.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding in the area has occurred in every month of the year, but most frequently occurs in the autumn, winter, and spring months. Floods are usually the result of intense rainfall, except near Lake Pontchartrain where inundation results from high tides and excessive precipitation. Generally, the upstream reaches flood several times each year. Most floods are of short duration, but may vary between areas and causes. Flooding may result from any of three causes acting singly or in combination. The types of flooding which threaten the area include the following:

Mississippi River Flooding

Lands adjacent to the Mississippi River are subject to flooding due to high stages in the Mississippi River. For all practical purposes, this type of flooding is generated by runoff originating outside of the planning area.

Headwater Flooding

Lands along various drainage arteries are subject to flooding due to high stages in the various streams generated by excessive runoff originating within the watershed tributary to the artery in question.

Rural flooding, Comite River Basin, April 1967.

Tidal Flooding

Lands along the shore of Lake Pontchartrain or adjacent to tidal streams are subject to overflow by tidal surges associated with hurricanes and tropical storms.

Major Historical Floods

General flooding throughout WRPA 8 occurred in 1953, 1962, 1964, and 1973. A description of these significant floods follows.

1953 Flood

The flood of May 1953 was caused by unusually heavy rains beginning on 27 April. During the period 22 April-9 May 1953 heavy rainfall produced generally high stages on most streams in the area and set the stage for additional flooding following a second storm period between 10-21 May 1953. During the second storm period, rainfall in the area ranged from 17.5 inches at New Roads to 5.9 inches at Livingston and 3.4 inches at French Settlement. The average rainfall for the total storm period 22 April-21 May over the area was about 18 inches.

The flood overflowed an area of 807,700 acres and resulted in an estimated \$5,672,000 of damages, of which \$3,328,000 was to crops and pasture, \$2,300,000 was direct non-crop damages, and \$44,000 was indirect non-crop damage.

1962 Flood

The flood of April 1962 was caused by unusually heavy rains during the period 27-28 April 1962. The rainfall associated with the flood ranged from 4.0 inches at New Roads to 7.0 inches at Baton Rouge.

The flood overflowed an area in excess of 114,000 acres in the Choctaw, Amite, and Tickfaw River Basins. Estimated damages that resulted were \$298,000.

1964 Flood

Hurricane Hilda during the period 3-5 October 1964 caused extensive tidal and headwater flooding in WRPA 8. The center of the hurricane moved inland at Franklin, Louisiana, in St. Mary Parish on the evening of 3 October and followed a northeasterly course which crossed WRPA 8. The accompanying winds caused a tidal buildup of 6-7 feet above normal along the north shore of Lake Pontchartrain. Rainfall in WRPA 8 associated with this hurricane ranged from 10.1 inches at New Roads and 8.9 inches at Baton Rouge to 2.1 inches at Hammond.

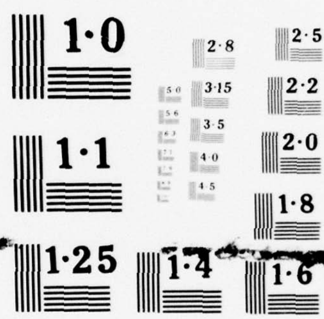
Approximately 607,100 acres were flooded in the area, 299,600 acres by excessive tides, and 307,500 acres by headwater flooding. An estimated \$1,417,000 in damages resulted from this hurricane, consisting of \$373,000 from headwater flooding, \$45,000 from tidal overflow, \$977,000 from wind, and \$32,000 from other losses.

AD-A041 354 LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY COORDINA--ETC F/G 8/6
LOWER MISSISSIPPI REGION COMPREHENSIVE STUDY. APPENDIX E. FLOOD--ETC(U)
1974

UNCLASSIFIED NL

3 OF 3
ADA
041354

END
DATE
FILMED
7-77



NATIONAL BUREAU OF STANDARDS
MICROCOPY RESOLUTION TEST CHART

1973 Flood

During the Spring of 1973 flooding occurred throughout WRPA 8 with each of its major Basins suffering damages. In the Lake Pontchartrain Basin many streams overflowed their banks flooding adjoining narrow strips of pasture and woods. Low-lying areas and the marshes near Lake Maurepas and Pontchartrain had wide spread inundation. Damages to urban and rural developed areas were relatively minor. Cropland in the south and southeast part of the Basin had serious but not devastating damages.

The Mississippi River Basin, on the east bank of the river, sustained overflow from the high stages in the river. Residential damage in this area was also of lesser consequence than damage to pasture and cropland.

In the area west of the Mississippi River the most serious flooding conditions were along the Atchafalaya Guide Levee. Residences, camps, and several commercial establishments suffered damages. Minor damage, caused by seepage and headwater flooding, also occurred to pasture and cropland near the alluvial bank of the Mississippi.

Compared to nearby WRPA's, damage in WRPA 8 was light, totalling $4.2 million, occurring over 527,000 acres inundated.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed flood control improvements that prevent damages from headwater, tidal, and Mississippi River floods. A summary of these improvements is given below in table 46. Detailed information on the improvements is contained in the Inventory of Facilities Appendix. Information on projects and studies underway and Federal agency authorities are contained in Appendix T, Plan Formulation.

Lands in the Pontchartrain Basin and the area west of the Mississippi River receive protection against Mississippi River overflow from flood control works on the Mississippi River and its tributaries that are an integral part of the entire program for the region. As part of the overall program for the region, a continuous levee system along the east bank of the Mississippi River below Baton Rouge provides protection to lands in the Pontchartrain Basin, and a continuous levee system on the west bank of the Mississippi River for its reach through WRPA 8, and the east guide levee of the Atchafalaya Basin Floodways provide protection to the area west of the Mississippi River. The program to control floods on the Mississippi River is under construction; and until the entire program is completed, the flood control plan will be only partially effective.

In the area west of the Mississippi River, natural drainage intercepted by construction of the east protection levee of the Atchafalaya Floodway has been provided by excavation of landside borrow pit drainage channels where necessary to provide a continuous artery east of the levee throughout its length.

The reduction of headwater flood damages has been provided in the Pontchartrain Basin by channel improvement on Amite River, Comite River, Bayou Manchac, Panama Canal-Conway Bayou, Little Tangipahoa River, Natalbany River, New River, Ponchatoula Creek, Selser's Creek, Tickfaw River and Yellow Water River. Hurricane protection improvements under construction in WRPA 10 for Lake Pontchartrain and vicinity provide tidal flood damage reduction for the low-lying lands along the shores of Lake Pontchartrain and its tributaries in WRPA 8.

Local interests have constructed throughout the area numerous improvements that provide land drainage and protection against floods.

Table 46 - Summary of Local Protection Projects, 1970, WRPA 8[1/]

Basin	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Pontchartrain	-	135.9	-	-
Mississippi	-	-	-	-
Area West of the Mississippi River	-	48.2	-	-
Total	-	184.1	-	-

1/ Consists of projects in both upstream watersheds and principal reaches.

Land Treatment

Approximately 1.3 million acres in the WRPA are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Data on acres with adequate treatment by basin are shown on table 47.

Table 47 - Land Treatment, 1970, WRPA 8

Basin	Lands Adequately Treated Acres (1,000's)
Pontchartrain	924
Mississippi	161
Area West of the Mississippi River	183
Total	1,268

Nonstructural Program

Three Flood Plain Information reports are completed or underway in WRPA 8. These reports bring together a record of the largest known floods of the past and show the area that may be inundated by probable future floods.

Four flood insurance studies have been completed or are underway in WRPA 8. These studies identify flood hazard areas, develop flood frequency data, and compute preliminary data for areas identified by the Federal Insurance Administration.

Flood Forecasting

Hurricane, river and flood forecast and warnings are issued by the National Weather Service. Forecast dissemination is largely provided by news media through the use of the NOAA Weather Wire Service, a teletypewriter network available to all bona fide news disseminators.

Emergency Operations

The Federal Government, State, and local agencies have cooperated on numerous occasions when natural disasters such as floods and hurricanes have befallen the area. Emergency operations performed in the past have included evacuation and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and recovery operations.

Emergency sandbagging to prevent flooding on the Mississippi River Mile 234.5, March 1949.

Remaining Flood Problems

The major flood problems that remain in WRPA 8 are the results of inundation from streamflow caused by headwater flooding. Mississippi River flooding will be largely controlled when the Mississippi River and Tributaries project is completed; and tidal flooding will be reduced when the Lake Pontchartrain and Vicinity project presently under construction is completed.

The area remaining subject to flooding by Standard Project Floods with existing projects in place is 1.1 million acres along the principal reaches and about 1.0 million acres in the upstream watersheds. Although Standard Project Hurricane would inundate approximately 296,000 acres with projects in place, the area inundated is sparsely developed and resultant damages would be small. The Mississippi River design flood would overflow an area of 60,000 acres located in the unleveed areas north of Baton Rouge. Since flooding may result from several causes, the acreage subject to flooding by each cause is not additive. Urban and built-up places with average annual damages greater than $25,000 are shown on figure 23.

In the Lake Pontchartrain Basin, most flooding occurs within a narrow wooded bank adjacent to both sides of the streams. As the streams reach lower land elevations and the marsh area near Lake Pontchartrain, headwater floods fan out to inundate the low-lying area. Overflow in WRPA 8, except for infrequent large floods, is mostly confined to wooded areas and sparsely developed lowlands.

Damages from major floods on principal streams in the Amite River watershed occur in Baton Rouge, suburban areas surrounding Baton Rouge, and in Denham Springs. The rural communities of Port Vincent and French Settlement also sustain headwater flood damages. In the Tickfaw watershed, the major damage occurs in the urban areas of Hammond and Ponchatoula, and the rural communities of Springfield, Holden, and Albany. In the Tangipahoa River watershed, headwater flood damages occur primarily to agricultural land, although the rural community of Madisonville sustains flood damage. Other damages occur to cropland scattered throughout the Lake Pontchartrain Basin. Damages resulting from tidal flooding in the Lake Pontchartrain Basin are primarily rural in nature, consisting of damages to agriculture and scattered dwellings and farm buildings.

Flooding vicinity of Baker, Louisiana, April 1967.

In the area west of the Mississippi River, headwater flooding is the primary cause of flood damages. Damages in this area are small and rural in nature.

Table 48 summarizes the area subject to flooding and average annual damages by Standard Project Floods, Standard Project Hurricanes, and the Design Floods for the Mississippi River under existing development conditions. The data presented in this tabulation are based on the assumption that all projects now under construction are completed. However, in the area where major projects are under construction, additional lands are still subject to flooding, and damages of disastrous proportions could occur without completion of the projects. These damages and acreages are in addition to those presented in table 48.

Table 48 - Remaining Flood Problems, Existing Conditions, WRPA 8

Basin	Area Subject to Floods (1,000 Acres)		Average Annual Damages ($1,000) Damages Due to Flooding											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Pontchartrain														
Headwater Flood	752	510	93	829	6	928	1,539	808	506	2,853	1,632	1,637	512	3,781
Tidal Flood	296	-	0	3	0	3	-	-	-	-				
Mississippi														
Headwater Flood	-	53	-	-	-	-	102	-	35	137	102	-	35	137
Miss. River Flood	61	-	13	-	6	19	-	-	-	-	13	-	6	19
Area West of the Mississippi R.														
Headwater Flood	265	466	49	18	1	68	1,326	-	-	1,326	1,375	18	1	1,394
TOTALS														
Headwater Flood	1,017	1,029	142	847	7	996	2,967	808	541	4,316	3,109	1,655	548	5,312
Tidal Flood	296	-	-	3	-	3	-	-	-	-	-	3	-	3
Miss. River Flood	61	-	13	-	6	19	-	-	-	-	13	-	6	19
TOTAL						1,018				4,316				5,334

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a slightly higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources.

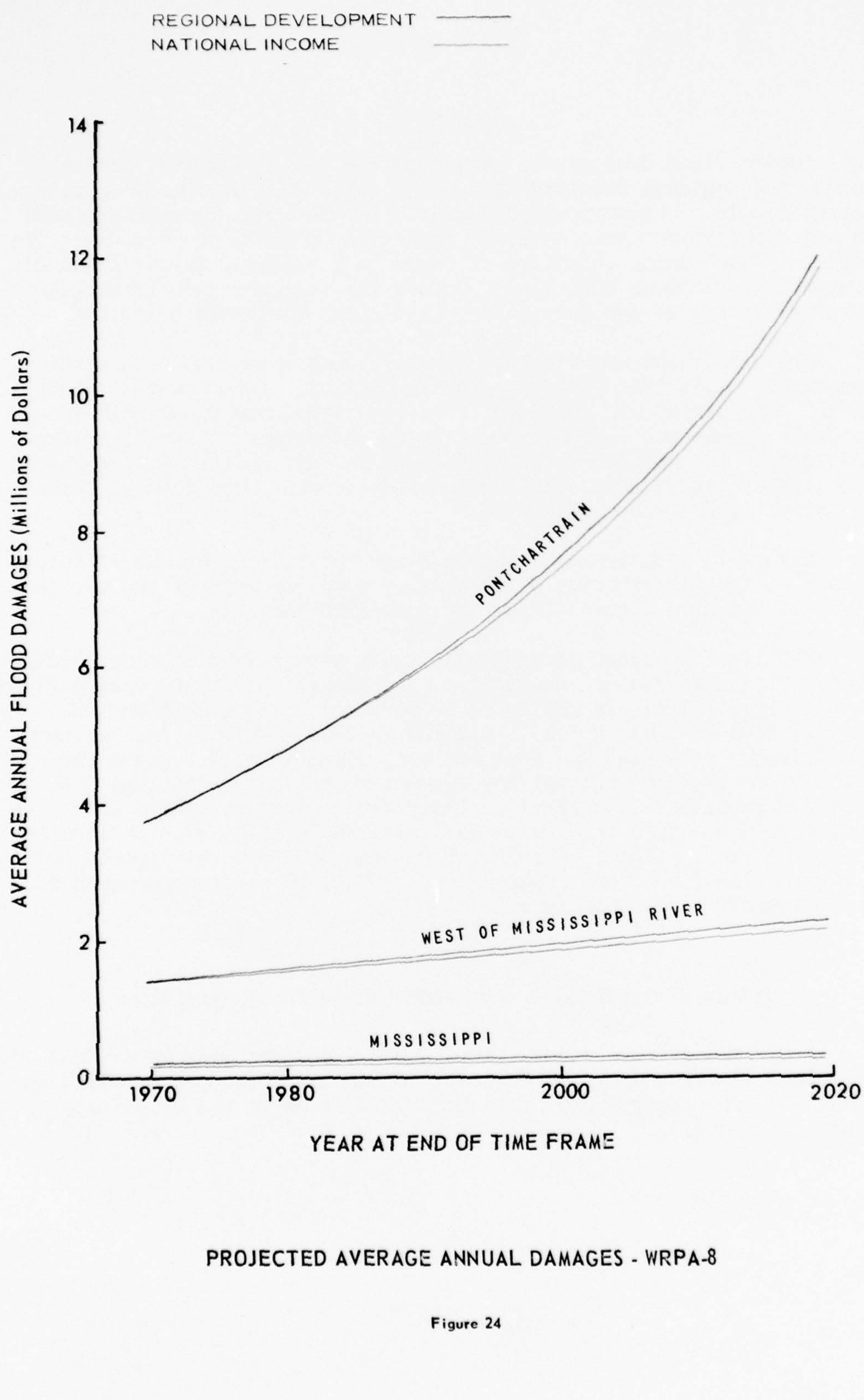
Projected land use indicates that further urban and agricultural development will take place in the floodplains. Future use of lands in the floodplains are expected to be about the same under both the National Income and Regional Development objectives. However, urban development is expected to be more dense and agricultural yields will be slightly higher under the Regional Development objective as compared to the National Income objective.

Figure 24 illustrates the trends and relative magnitude of future damages. The distribution of damages by type for each of the two objectives is shown in figure 25 for the year 1970 and 2020.

The level of flood damages that could result from Standard Project Floods, Standard Project Hurricanes, and Mississippi River Design Flood in principal reaches is estimated to be about $1.3 million in 1980, $2.1 million in 2000, and $3.5 million in 2020. This is the maximum flood damage potential and does not vary significantly between the National Income and Regional Development objective projections. In the upstream watersheds the level of flood damages are estimated under the National Income objective to be $5.2 million in 1980, $7.4 million in 2000, and $10.9 million in 2020. Under the Regional Development objective, the level of flood damages in the upstream watersheds would be approximately 1 percent higher.

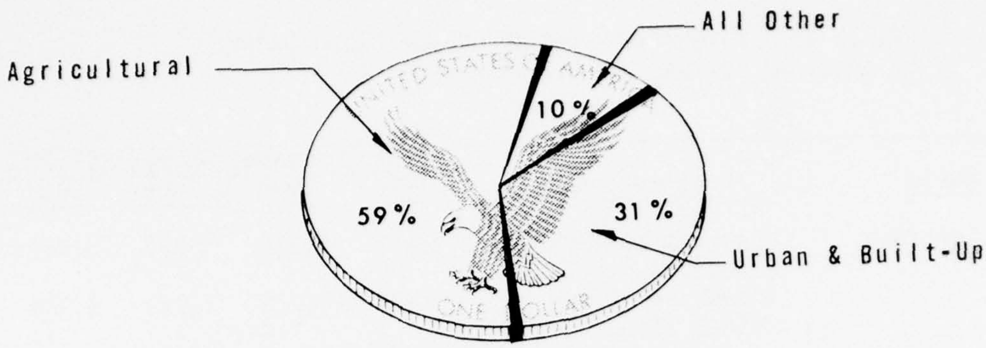
Future Flood Damages with National Income Growth Rate

Projected average annual flood damages for upstream watersheds and principal reaches under the National Income objective are provided in table 49. The damages are presented by major basin and by primary source of flooding.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-8

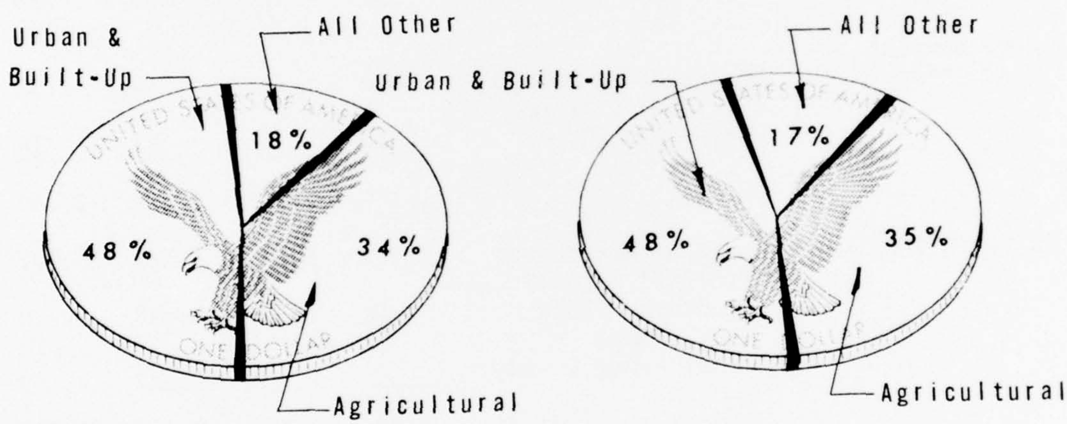
Figure 24



1970

NATIONAL INCOME

REGIONAL DEVELOPMENT



2020

DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-8

Figure 25

Table 49 - Projected Average Annual Flood Damages
National Income Growth, WRPA 8

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Pontchartrain	Upstream Watersheds	2,853	3,536	5,397	8,447
	Principal Streams				
	Headwater Flood	928	1,236	1,981	3,296
	Tidal Flood	3	5	7	11
	Total	3,784	4,777	7,385	11,754
Mississippi	Upstream Watersheds	137	162	224	322
	Principal Streams				
	Miss. River Flood	19	24	29	36
	Total	156	186	253	358
Area West of the Mississippi R.	Upstream Watersheds	1,326	1,472	1,764	2,132
	Principal Streams				
	Headwater Flood	68	82	97	114
	Total	1,394	1,554	1,861	2,246
WRPA TOTALS	Upstream Watersheds	4,316	5,170	7,385	10,901
	Principal Streams				
	Headwater Flood	996	1,318	2,078	3,410
	Tidal Flood	3	5	7	11
	Miss. River Flood	19	24	29	36
	Total	5,334	6,517	9,499	14,358

Future Flood Damages with Regional Development Growth Rate

The projected average annual flood damages for the planning area under the regional development growth rate are shown in table 50.

Table 50 - Projected Average Annual Flood Damages
Regional Development Growth, WRPA 8

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Pontchartrain	Upstream Watersheds	2,853	3,559	5,545	8,670
	Principal Streams				
	Headwater Flood	928	1,236	1,981	3,296
	Tidal Flood	3	5	7	11
	Total	3,784	4,800	7,533	11,977
Mississippi R.	Upstream Watersheds	137	162	230	328
	Principal Streams				
	Miss. River Flood	19	24	29	36
	Total	156	186	259	364
Area West of the Mississippi R.	Upstream Watersheds	1,326	1,472	1,809	2,143
	Principal Streams				
	Headwater Flood	68	82	97	114
	Total	1,394	1,554	1,906	2,257
WRPA TOTALS	Upstream Watersheds	4,316	5,193	7,584	11,141
	Principal Streams				
	Headwater Flood	996	1,318	2,078	3,410
	Tidal Flood	3	5	7	11
	Miss. River Flood	19	24	29	36
	Total	5,334	6,540	9,698	14,598

WRPA 9

W R P A 9

DESCRIPTION

General

WRPA 9 covers an area, roughly rectangular in shape, of 13,296 square miles in southwest Louisiana (see figure 26). The eastern boundary is the Mississippi River levee and the east Atchafalaya Basin protection levee. On the west, the WRPA is bounded by the Sabine River Basin. The Gulf of Mexico is the southern boundary. The northern boundary extends westward from the Mississippi River levee at Black Hawk to the Red River, then follows the south bank of Red River to Boyce, Louisiana, and thence along the southern boundary of the Red River Basin.

Topography

The terrain consists of hills, prairies, alluvial lowlands, and coastal marshes. A well-defined bluff line known as the Opelousas Escarpment, which generally follows a north-south direction about 2 to 8 miles west of Bayou Teche, marks the divide between the alluvial lowlands in the eastern portion of the area and the hill lands and prairie region to the west. Coastal marshes extend inland from the Gulf of Mexico a distance of 20 to 30 miles along the southern portion of the WRPA.

In the hill lands, ground elevations vary from about 250 feet[1/] southwest of Boyce, Louisiana, to about 20 feet at New Iberia, Louisiana. Here the landscape is largely covered by second-growth pine forests and the streams are confined in well-defined valleys with steep sides. The prairies are generally flat, with elevations around 10 feet, and slope gently south. Most of the prairie lands are in cultivation, and trees are usually found growing only along stream banks. A number of waterways in the prairie region have natural and artificial connections that link them into a complicated system. In the alluvial lowlands, the surface slopes are very flat and large areas of poorly drained land are evident. The coastal marshland is an area of very low relief. Except for narrow "chenieres" or sand ridges, the area is less than 2 feet in elevation. The sand ridges, which are old beach lines, parallel the coast and have a maximum elevation of about 11 feet.

The WRPA has four major drainage areas and numerous minor drainages in the coastal zone. The major drainage areas are the Calcasieu River Basin, the Mermentau River Basin, the Bayou Teche-Vermilion River Basin, and the Atchafalaya Basin. These basins are shown on figure 26.

1/ All elevations refer to mean sea level unless otherwise specified.

The Calcasieu River Basin has an area of 4,100 square miles, including minor associated drainage areas near the coast. Calcasieu River, the major stream in the basin, rises in the low hill lands and flows about 215 miles through hill lands, prairies, and coastal marshes to the Gulf of Mexico. Principal tributaries of Calcasieu River are Whiskey Chitto Creek, Barnes Creek, West Fork Calcasieu River, Bayou Serpent, and English Bayou. The tributary streams are generally normal to the river and the main ones have well-defined meander channels and alluvial valleys.

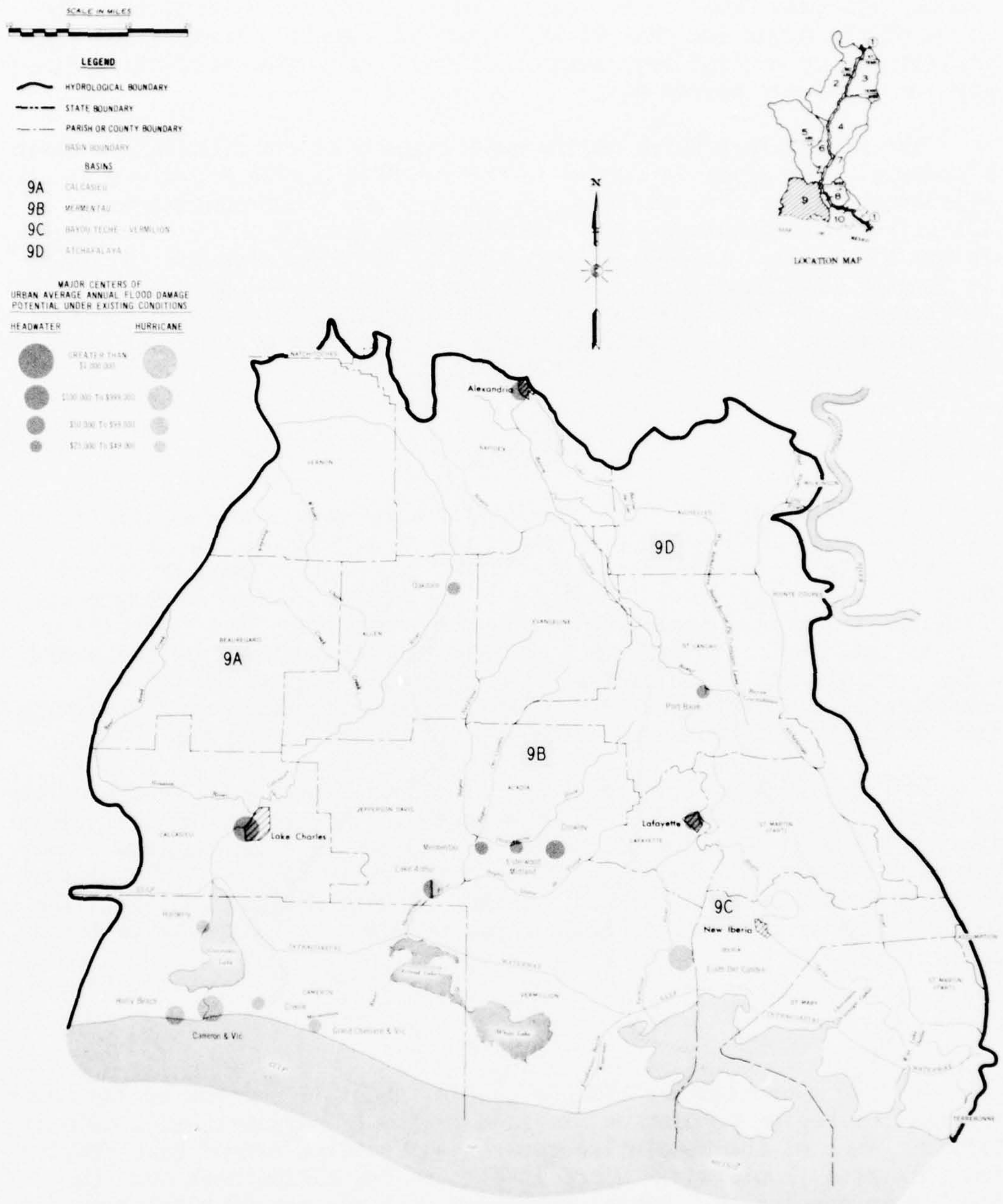
The Mermentau River Basin drains 3,896 square miles, including minor drainages in the coastal zone associated with the basin. Mermentau River, the major stream in the basin, is formed by the junction of Bayous Nezpique and des Cannes. The river flows 72 miles in a southerly direction through prairies and coastal marshes to the Gulf of Mexico. Major tributaries of the Mermentau River are Bayous Nezpique, des Cannes, Plaquemine Brule, Lacassine, and Queue de Tortue.

The Bayou Teche-Vermilion River Basin has a drainage area of 2,014 square miles and lies within the alluvial lowlands and coastal marshes. Major streams in the drainage area are Vermilion River, Bayou Teche, and the west Atchafalaya Basin protection levee borrow pit below Bayou Courtableau.

Bayou Teche has its source in Bayou Courtableau at Port Barre, Louisiana, and flows in a generally southeasterly direction a distance of 125 miles to its junction with the Lower Atchafalaya River. The stream functions principally to convey drainage from the Bayou Rapides-Bayou Cocodrie-Bayou Courtableau-west Atchafalaya Basin protection levee borrow pit system in the Atchafalaya Basin to the Vermilion River and lower Bayou Teche. Bayou Teche is connected to the Vermilion River, both at its head through Bayou Fusilier and the privately-owned Ruth Canal. Vermilion River is formed by the junction of Bayous Bourbeaux and Fusilier and flows about 72 miles in a south to southwesterly direction to Vermilion Bay. Vermilion River also functions as a distributary of Bayou Teche. The west Atchafalaya Basin protection levee borrow pit is a system of natural and artificial channels which generally parallel the west Atchafalaya Floodway protection levee and provide an outlet for natural drainage intercepted by the levee.

The Atchafalaya River Basin, a complex combination of natural and artificial watercourses, may be subdivided into three parts - (1) the area west of the west Atchafalaya Basin protection levee, and (2) the Atchafalaya Basin Floodways, and (3) the area east of the east Atchafalaya River protection levee.

In the area west of the floodways, the major streams are Bayous Rapides, Boeuf, and Cocodrie diversion channel on the west, the upper portion of the west Atchafalaya Basin protection levee borrow pit and



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 9 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 26

the Chatlin Lake Canal on the east. Bayou Courtableau intercepts the flows of the diversion channel and upper borrow pit. These flows are distributed by control structures to Bayou Teche, the Atchafalaya Floodway, or the lower borrow pit.

The Atchafalaya River is the major stream in the Atchafalaya Basin Floodways. The river is formed by the junction of the Red River and the Mississippi River through Old River Control and flows southward for 135 miles to Atchafalaya Bay. The floodways through which the Atchafalaya River flows include an area roughly 15 miles wide and 100 miles in length. The lower half of the floodway consists of an area of lakes and swamps with multiple channels which discharge into the gulf. The portion of the Atchafalaya River Basin located east of the east Atchafalaya protection levee lies outside of the WRPA.

Climate

The climate of WRPA 9 is characterized by mild winters, relatively heavy precipitation, and hot summers. It is greatly influenced by numerous streams and lakes which moderate temperature conditions and changes. Southerly winds from the Gulf of Mexico further moderate the climate, giving it a semi-tropical marine character. Heavy precipitation in this WRPA results from such climatic actions as tropical hurricanes moving northward over the area, intensive convective storms caused by proximity to the Gulf of Mexico, and frontal storms resulting from action between moist maritime and cold polar air masses.

The average annual temperature is 68.3 F. The normal length of the frost-free growing period is about 8 months. The average annual precipitation based on 30 years of record is 59.3 inches. The maximum annual rainfall recorded was 111.3 inches at Morgan City in 1946. The minimum annual rainfall recorded was 30.1 inches at Lake Charles in 1954. The maximum monthly rainfall of 38.0 inches occurred at Lafayette in August 1940.

Economy

In 1970 approximately 748,000 people, about 12 percent of the Lower Mississippi Region population, resided in the 14 parishes which comprise WRPA 9. Much of the population growth has centered around Lake Charles and Lafayette, Louisiana. Since 1940 these two cities have more than doubled in population. Urban population as a percent of total population was 58 percent in 1970. Cities with populations of 10,000 or more include Abbeville, Crowley, Eunice, Jennings, Lafayette, Lake Charles, New Iberia, Opelousas, South Fort Polk, and Sulphur. There are 25 towns with populations between 2,500 and 10,000, and 39 towns with populations between 500 and 2,500. Population is projected to increase to 994,000

in 2020 under the Regional Development objective. Most population increases are expected to occur in the Lake Charles and Lafayette metropolitan areas, with the overall trend toward a more urbanized population.

Significant economic activities in the area include mineral production, petroleum and chemical processing, agriculture, commercial fishing, processing of food products, waterborne commerce, harvesting and processing of forest products, fur trapping, and service industries. In addition, the numerous lakes and streams of the area, and the vast marshland and swamps represent an enormous recreation resource.

The development of oil and natural gas resources is the major contributor to the economic progress of the area. In addition, the area has large reserves of salt, sulphur, sand and gravel, and clays. The total value of mineral production in 1969 was about $1.53 billion. By 2020 production is projected to more than double under the National Income objective and to almost triple under the Regional Development objective.

The major manufacturing industry categories in the area are chemical and allied products, petroleum refining, food and kindred products, and paper and allied products. The 1968 manufacturing gross product was about $369 million and is expected to increase about 760 percent under the National Income objective and 900 percent under the Regional Development objective by 2020.

Another significant segment of the area's economy is agriculture. Major agricultural pursuits include production of rice, sugar cane, soybeans, and the raising of livestock and poultry. In the future, agriculture production will remain a major factor in the economy, with the value of production sold nearly doubling by 2020 under the National Income objective and slightly more than doubling under the Regional Development objective by 2020.

Land use in the planning area, a total of about 8 1/2 million acres, consists of cropland, 30 percent; pasture, 11 percent; forests and woodlands, 40 percent; urban and built-up lands, 3 percent; water areas, 7 percent; and other lands about 9 percent. Urban lands are expected to more than double by 2020. Cropland and pasture are also expected to significantly increase. As a result, decreases will occur in forest lands and other lands.

Land transportation in the area is provided by one interstate highway, four Federal highways, numerous State and local roads, and five railways. There are numerous navigable waterways in the area, including the Calcasieu, Mermentau, Vermilion, and Atchafalaya Rivers and the Gulf Intracoastal Waterway. The port of Lake Charles, located on the Calcasieu River, is the third largest port in the region in terms of tonnage moved.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Flooding generally occurs during spring to early autumn. Floods are usually of a relatively long duration and result from intense rainfall, except in the coastal area where inundation results from high tides or a combination of both. Flooding in the area may be categorized into three distinct types of flooding which may occur singly or in combination:

Mississippi River and/or Red River Flooding

Lands adjacent to the Red River and Atchafalaya River are subject to flooding due to high stages in these rivers which result from high stages in the Mississippi River "backing up" water in the Red River and diverting flow to the Atchafalaya River. Lands adjacent to the Red River are also subject to flooding due to high stages caused by excessive rainfall in the Red River Basin. Both Mississippi River flooding and Red River flooding are primarily the result of runoff originating outside the planning area.

Headwater Flooding

Lands along various drainage arteries are subject to flooding due to high stages which are generated by runoff originating within the watershed tributary to the artery in question.

Tidal Flooding

Lands along the coast or adjacent to tidal streams are subject to overflow by tidal surges associated with hurricanes and tropical storms.

Major Historical Floods

General flooding throughout WRPA 9 occurred in 1940, 1953, 1957, 1961, and 1973. A description of these significant floods follows.

1940 Flood

A storm of tropical origin between 6-10 August produced this flood. Prior to the storm, daily rains ranging from a few tenths of an inch to falls of 2 to 3 inches occurred during the latter part of July and the first 5 days of August throughout nearly all of WRPA 9. Saturated soil conditions, due to the supply of irrigation water for rice crops, coupled with preceding rains, were such prior to the storm rainfall as to cause maximum runoff during and subsequent to the time of the storm's occurrence. During the 4-day period, 6-9 August, rainfall of 31.66 inches occurred at Abbeville and 33.71 inches occurred at Crowley. In many localities, low areas remained flooded until mid-October.

Vicinity of Gueydan, Louisiana, during flood of August 1940.

Approximately 1,920,000 acres of agricultural, grazing, trapping, and timbered lands were overflowed by the flood to depths of 1 to 6 feet. An estimated $8,990,000 of damages resulted from the flood, of which $6,525,000 was to crops, $940,000 to livestock, $875,000 was property damage, and $650,000 represented relief expenditures. Evacuation of some 18,000 persons from the flooded areas very probably prevented considerable loss of life.

1953 Flood

The flood of May 1953 was caused by unusually heavy rains beginning 27 April. There were two defined periods of heavy rainfall occurring intermittently, 27 April-5 May and 11-19 May. The first storm produced high stages on all streams in the area and set the stage for the widespread disastrous flood that followed the second storm period. The culminating factor was the 24-hour rain on 18 May, when amounts up to 13 inches were recorded.

The flood overflowed an area of 2,038,000 acres in the drainage basins west of the west Atchafalaya Basin protection levee and resulted in an estimated $19,591,000 of damages, of which $12,500,000 was to crops and pasture, $5,071,000 was direct non-crop damage, and $2,020,000 was indirect non-crop damage.

1957 Flood

Hurricane Audrey during the period 25-28 June was the cause of this flood. The center of the hurricane moved inland at Cameron Parish on the morning of 27 June. Offshore waves were as high as 50 feet and waves striking the area at Cameron were reported to be 20 feet above sea level. Tides were very high along the coast, with reports of 11.9 feet at Grand Cheniere, 12.5 feet at Cameron, 10.9 feet at Pecan Island, and 8.5 feet at Morgan City. Heavy rains accompanied the storm and at least two tornadoes were reported to have been caused by the hurricane.

Approximately 1,615,000 acres in WRPA 9 were flooded by excessive tides and headwater flooding. An estimated $41,525,000 in damages resulted from this hurricane in WRPA 9, of which $32,913,000 were non-crop damages and $8,612,000 were crop damages. This hurricane was responsible for the loss of 556 lives which were lost primarily because people failed to evacuate the coast in time to escape the rapidly rising waters.

1961 Flood

Hurricane Carla, which is considered one of the major gulf hurricanes of the century, produced the flood during the period 4-14 September. Although the center of the storm moved inland at Matagorda on the central Texas coast, high wind velocities and tides were recorded all along the Louisiana coast. The rainfall, accompanying the hurricane, within WRPA 9 ranged from moderate to moderately heavy. Low stages were prevalent in all streams prior to these rains. The rains caused the upper Calcasieu River to rise to slightly above flood stage. Essentially, all flooding along coastal streams resulted from tidal overflow. Tides along the coast in WRPA 9 ranged from 6.6 feet at Cameron to 7.5 feet at Grand Cheniere. Approximately 1,436,000 acres in WRPA 9 were flooded. Damages resulting from the storm amounted to $6,046,000, of which $4,327,000 were non-crop damages and $1,722,000 were crop damages.

1973 Flood

During the Spring of 1973 certain areas of WRPA 9 experienced severe flooding which originated from several sources. Backwater flooding from the Mississippi-Red-Black-Rivers System resulted in severe inundation and immense damages to development and agricultural production in the Red River backwater area, located in the upper northeast portion of the Area. Thousands of acres of soybean and pasture land were flooded for periods exceeding three months. Prolonged rainfall and inadequate drainage also resulted in significant overflow in the vicinity of Alexandria to Opelousas and immediately landside of the West Atchafalaya Floodway guide levee.

Flood conditions on the Mississippi River forced the opening of the Morganza Floodway, for the first time in its history, on April 17, 1973. Peak stages on the Atchafalaya River resulted in substantial inundation to the majority of land in the Atchafalaya Basin Floodway. Oil and gas

industry activities were severely damaged basin-wide and all industrial development on the riverside of the Atchafalaya Floodway guide levees in the vicinity of Berwick and Morgan City suffered disastrous losses.

Generally, below U. S. Highway 190, the Calcasieu, Mermentau, Teche, and Vermilion Rivers and their respective tributaries were unable to accommodate excessive flows due to persistent precipitation resulting in overflow to adjacent agricultural lands. Along the Gulf coast portion of the Area, high tides and sustained southerly winds resulted in tidal flooding which inundated all low-lying coastal areas. In the Calcasieu, Mermentau, Teche, and Vermilion Basins, the crops receiving the greatest damages were rice, sugar cane, and soybeans.

In summary, an estimated 765,000 acres were flooded from tidal action while 1,886,000 acres were flooded from headwater and other causes. Approximately $67.6 million damage was sustained in WRPA 9 on the 2,651,000 total acres inundated.

PRESENT CONTROL PROGRAM AND REMAINING DAMAGES

Existing Flood Damage Prevention Program

Structural Program

The Federal Government in cooperation with local interests has constructed flood control improvements that give partial protection from headwater, tidal, Mississippi River, and Red River floods. A summary of these improvements is given below and in tables 51 and 52. Detailed information on the improvements is contained in the Inventory of Facilities Appendix. Information on projects and studies underway and Federal agency authorities are contained in Appendix T, Plan Formulation.

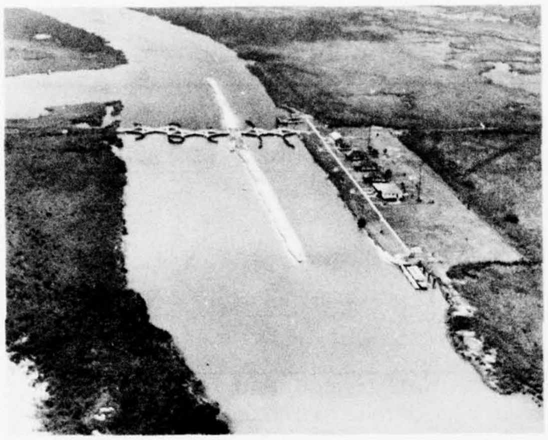
Lands receiving protection in the Calcasieu River Basin are located along Bayou Choupique and in the Bear Creek, Cameron-Creole, and English Bayou watersheds. Flood control improvements in the existing program are directed toward reducing damages that result from headwater flooding. The flood control measures on Bayou Choupique include channel enlargement, a diversion channel, and a control structure. Measures in three watersheds consist of flow retardation structures, control structures, levees, and channel improvements.

In the Mermentau River Basin, lands along the river receive protection from channel improvements which increase the headwater flood discharge capacities in the lower portion of the basin. Flow retardation structures and channel improvements reduce headwater flood damages in the tributary watersheds of Bayou Blue, Bayou des Cannes, Upper Bayou Nezpique, and the west fork of Bayou Lacassine.

Flood control improvements to reduce damages from Mississippi River, Red River, headwater, and tidal flooding are located in the Bayou Teche-Vermilion River Basin and the Atchafalaya Basin. Flood protection works to control floods on the Mississippi River and its tributaries are an integral part of the entire program for the region. In this area, a part of the floodwaters is diverted from the Mississippi River to an enlarged Atchafalaya River and through the floodways to the Gulf. The floodway program is under construction and until the entire program is completed the flood control plan will be only partially effective. Improvement of the natural streams and artificial waterways in the area provides for drainage interrupted by the floodways and reduction of headwater flooding. Because the low-lying topography in the basins is not conducive to reservoir construction, measures implemented have been limited to channel clearing, enlargement and realignment, diversion channels, levees, and control structures. Measures to provide hurricane flood protection for developed areas in the vicinity of Morgan City are under construction. These measures include construction of levees, pumping plants, and control structures.

Local interests have further provided protection through numerous drainage improvements in the area.

Old River control structures regulate flows from the Mississippi River into the Atchafalaya River Basin.



Catfish Point Control Structure on the lower Mermentau River regulates flood flows and prevents salt-water intrusion in the Mermentau River.

Charenton Floodgate regulates flood flows between Bayou Teche and the Atchafalaya Basin Floodway.

Table 51 - Flood Control Storage, 1970, WRPA 9

Basin	Flood Control - Storage in 1,000 Acre-Feet		
	Major Reservoir	Upstream Reservoir	Totals
Calcasieu	-	2.056	2.056
Mermentau	-	59.240	59.240
Bayou Teche-Vermilion	-	-	-
Atchafalaya	-	-	-
Total	-	61.296	61.296

Table 52 - Summary of Local Protection Projects, 1970, WRPA 9 1/

Basin	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Calcasieu	19	97	-	-
Mermentau	-	430	-	-
Bayou Teche-Vermilion	3	602	-	-
Atchafalaya	504	682	9	3,102
Total	526	1,811	9	3,102

1/ Consists of projects in both upstream watersheds and principal reaches. Works in the Atchafalaya Floodways are excluded.

Land Treatment

Approximately 2-1/2 million acres in the WRPA are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Data on acres with adequate treatment by basin are shown on table 53.

Table 53 - Land Treatment, 1970, WRPA 9

Basin	Lands Adequately Treated Acres (1,000's)
Calcasieu	743
Mermentau	643
Bayou Teche-Vermilion	372
Atchafalaya	777
Total	2,535

Nonstructural Program

Four Flood Plain Information reports have been completed or are underway in WRPA 9.

Three Flood Plain Insurance studies have been completed or are underway.

Flood Forecasting

River and flood forecast service, including flash flood warnings, is provided by NOAA Weather Service office at Lake Charles, Louisiana, and hurricane forecasts are provided by the NOAA Weather Service office at New Orleans, Louisiana. Forecast dissemination is largely provided by news media through the use of the NOAA Weather Wire Service, a teletypewriter network available to all bona fide mass news disseminators.

Emergency Operations

The Federal Government, State, and local agencies have cooperated on numerous occasions when natural disasters such as floods and hurricanes have befallen the area. Emergency operations performed in the past have included evacuation and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and recovery operations.

Remaining Flood Problems

The major flood problems remaining in the area are the results of inundations from streamflow, storms, and tidal action. Mississippi River and Red River flooding will be largely controlled when projects presently under construction are completed. An area of 2.9 million acres along the principal reaches and about 4.9 million acres in upstream watersheds are subject to flooding by Standard Project Floods with existing projects in place. Standard Project Hurricanes would result in flooding of about 1.9 million acres, and Mississippi River

and Red River design floods would overflow an area of 822,000 acres, most of which is in the Atchafalaya Basin Floodway. Since flooding may result from several causes, the acreage subject to flooding by each cause stated above is not additive. Urban and built-up places subject to flooding with average annual damages of $25,000 or more are shown in figure 26.

In the Calcasieu River Basin, flooding along Calcasieu River below the crossing of Louisiana Highway No. 28 occurs within a narrow bank adjacent to both sides of the river until just below the city of Lake Charles, at which point headwater floods fan out to inundate the low-lying coastal zone. The major damages above Lake Charles occur in the western part of the town of Oakdale. Other damages mainly on cropland are scattered throughout the area. Below Lake Charles, headwater flooding occurs in the urban area of Lake Charles and in built-up areas of Cameron and Holly Beach. These built-up areas sustain damage from hurricane tidal overflow in addition to headwater flooding. Inundation of the coastal zone from headwater and tidal flooding also results in damages to the agricultural and petroleum industries.

In the Mermentau River Basin, damages in the floodplain of Bayou Nezpique and Mermentau River below the Allen-Jefferson Davis Parish line are generally of the same type as in the Calcasieu River Basin. Major floods would inflict damages in the built-up areas of Crowley, Mermentau, Grand Cheniere, and Lake Arthur. Other improvements subject to flooding by a major flood include highway and railroad transportation facilities, oilfield equipment, and crop and pasture lands.

In the Bayou Teche-Vermilion River Basin, damages from major floods would be mainly to improvements in built-up areas. Lafayette, Erath, Delcambre, and numerous small communities in the vicinity of New Iberia would receive damage from headwater flooding and extensive damage from tidal flooding.

In the Atchafalaya Basin, headwater flooding is the major cause of flood damages. Mississippi River and Red River flooding is restricted primarily to the Mississippi River-Red River backwater area located in the northeastern part of WRPA 9 and in the Atchafalaya Floodways. Damages in the area are mainly agricultural.

Table 54 summarizes the area subject to flooding and average annual damages by Standard Project Floods, Standard Project Hurricanes, and the Design Floods for the Mississippi River and Red River under existing development conditions. The data presented in this tabulation are based on the assumption that all projects under construction prior to F.Y. 1974 are completed. However, in the area where major projects are under construction, additional lands are still subject to flooding and damages of disastrous proportions could occur without completion of the projects. These damages and acreages are in addition to those presented in table 54.

Table 54 - Remaining Flood Problems, Existing Conditions, WRPA 9

Basin	Area Subject to Floods (1,000 Acres) Principal Streams	Area Subject to Floods (1,000 Acres) Upstream Watersheds	Average Annual Damages ($1,000) Damages Due to Flooding: Principal Streams Agricultural	Principal Streams Urban & Built-up	Principal Streams Other	Principal Streams Total	Upstream Watersheds Agricultural	Upstream Watersheds Urban & Built-up	Upstream Watersheds Other	Upstream Watersheds Total	Total Agricultural	Total Urban & Built-up	Total Other	Total Total
Calcasieu														
Headwater Flood	533	789	91	314	72	477	1,587	31	97	1,715	1,678	345	169	2,192
Tidal Flood	329	-	59	1,417	794	2,270	-	-	-	-	59	1,417	794	2,270
Mermentau														
Headwater Flood	957	1,600	268	240	95	603	3,128	10	14	3,152	3,396	250	109	3,755
Tidal Flood	880	-	78	184	115	377	-	-	-	-	78	184	115	377
Bayou Teche-Vermilion														
Headwater Flood	260	917	49	8	11	68	2,265	-	-	2,265	2,314	8	11	2,333
Tidal Flood	371	-	69	328	170	567	-	-	-	-	69	328	170	567
Atchafalaya														
Headwater Flood	970	1,572	181	57	46	234	1,993	-	-	1,993	2,174	57	46	2,277
Tidal Flood	335	-	17	-	61	78	-	-	-	-	17	-	61	78
Miss. River-Red R.	822	-	64	-	-	64	-	-	-	-	64	-	-	64
TOTALS														
Headwater Flood	2,720	4,879	589	619	224	1,432	8,973	41	111	9,125	9,562	660	335	10,557
Tidal Flood	1,915	-	223	1,929	1,140	3,292	-	-	-	-	223	1,929	1,140	3,292
Miss. River-Red R.	822	-	64	-	-	64	-	-	-	-	64	-	-	64
TOTAL						4,788				9,125				13,913

Flooding after record rain, vicinity of Crowley and Jennings.

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development. These objectives are based on alternative levels of economic development. The National Income objective is based on the economic activity indicated by OBERS projections. The Regional Development objective is based on a slightly higher level of economic development that would improve the region's industrial comparative advantage and more fully utilize the available resources.

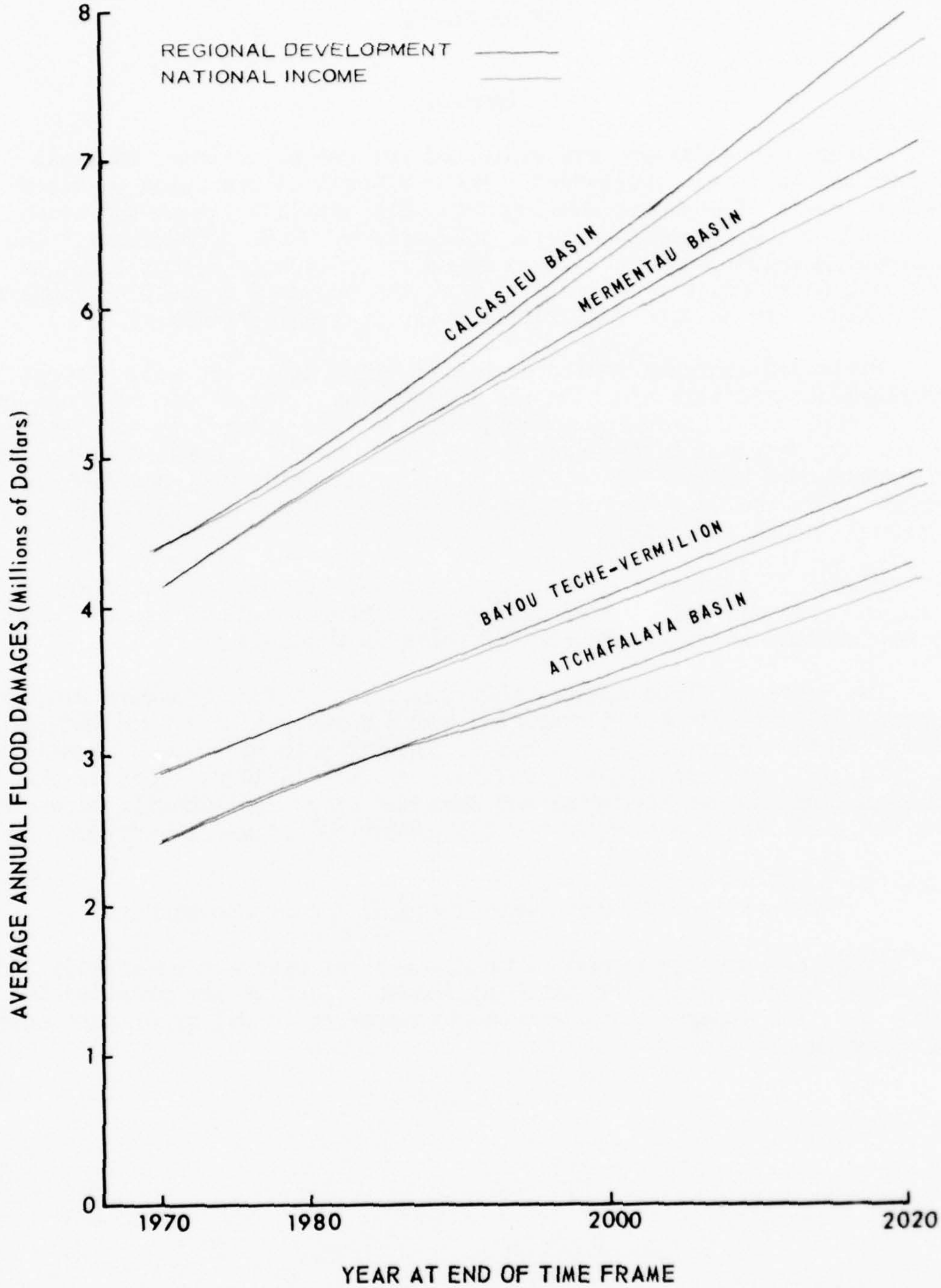
Projected land use indicates that further urban and agricultural development will take place in the floodplains. Future use of lands in the floodplains is expected to be about the same under both the National Income and Regional Development objectives. However, urban development is expected to be more dense and agricultural yields will be slightly higher under the Regional Development objective as compared to the National Income objective.

Figure 27 illustrates the trends and relative magnitude of future damages. The distribution of damages by type for each of the two objectives is shown in figure 28 for the years 1970 and 2020.

The level of flood damages that could result from Standard Project Floods, Standard Project Hurricanes, and Mississippi River and Red River Design Floods in principal reaches is estimated to be about \$5.6 million in 1980, \$6.7 million in 2000, and \$8.1 million in 2020. This is the maximum flood damage potential and does not vary significantly between the National Income and Regional Development objective projections.

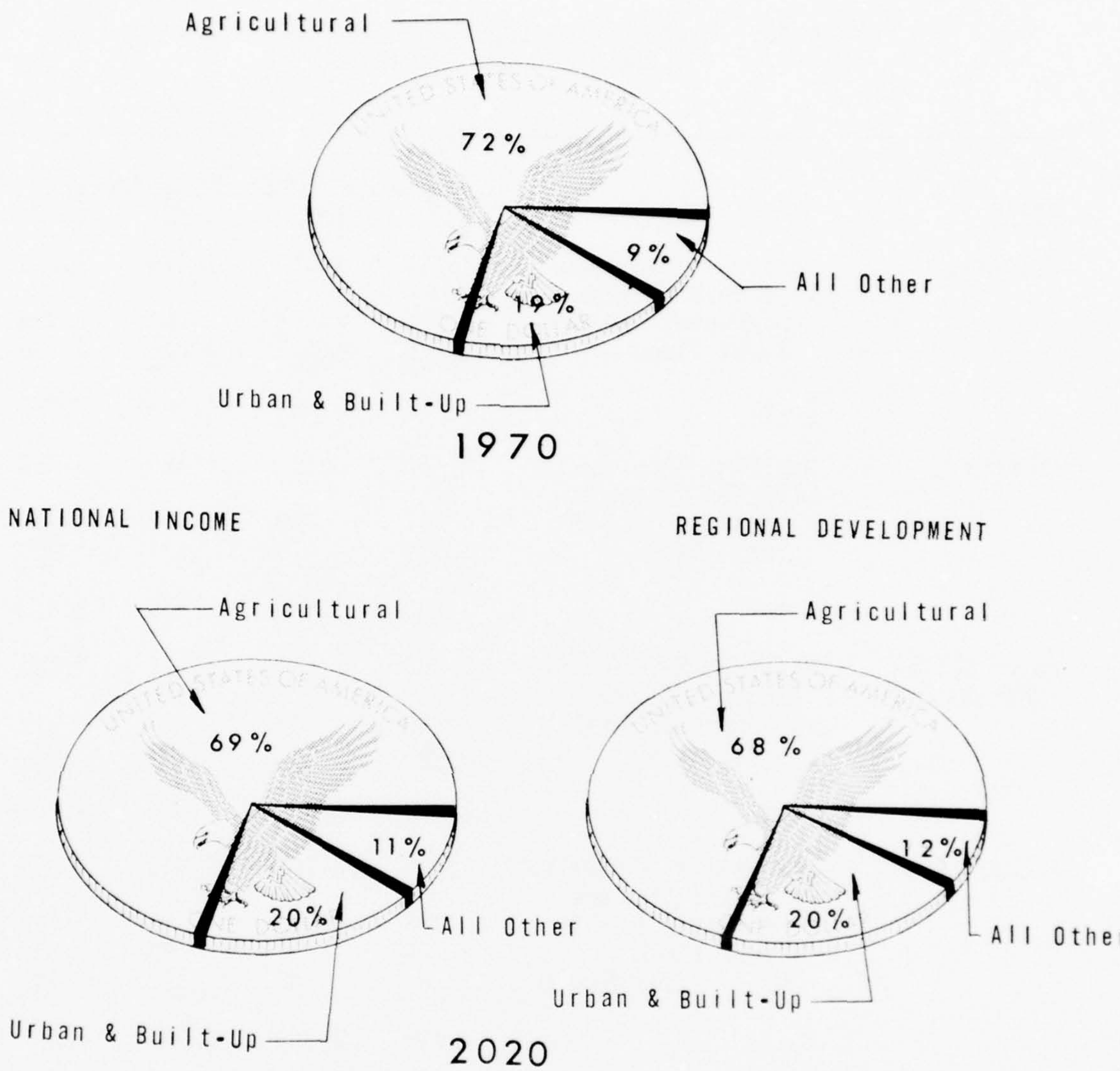
Future Flood Damages with National Income Growth Rate

Projected average annual flood damages for upstream watersheds and principal reaches under the National Income objective are provided in table 55. The damages are presented by major basin and by primary source of flooding.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-9

Figure 27



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-9

Figure 28

Table 55 - Projected Average Annual Flood Damages
National Income Growth, WRPA 9

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Calcasieu	Upstream Watersheds	1,715	1,987	2,580	3,216
	Principal Streams				
	Headwater Flood	477	554	660	784
	Tidal Flood	2,270	2,522	3,068	3,736
	Total	4,462	5,063	6,308	7,736
Mermentau	Upstream Watersheds	3,152	3,594	4,486	5,257
	Principal Streams				
	Headwater Flood	603	748	862	988
	Tidal Flood	377	437	521	623
	Total	4,132	4,779	5,869	6,868
Bayou Teche-Vermilion	Upstream Watersheds	2,265	2,577	3,202	3,723
	Principal Streams				
	Headwater Flood	68	89	100	117
	Tidal Flood	567	642	761	903
	Total	2,900	3,308	4,063	4,743
Atchafalaya	Upstream Watersheds	1,993	2,268	2,818	3,276
	Principal Streams				
	Headwater Flood	284	433	546	658
	Tidal Flood	78	82	93	106
	Miss. River Flood	64	82	102	147
	Total	2,419	2,865	3,559	4,187
WRPA TOTALS	Upstream Watersheds	9,125	10,426	13,086	15,473
	Principal Streams				
	Headwater Flood	1,432	1,824	2,168	2,547
	Tidal Flood	3,292	3,683	4,443	5,368
	Miss. River Flood	64	82	102	147
	Total	13,913	16,015	19,799	23,535

Future Flood Damages with Regional Development Growth Rate

The projected average annual flood damages for the planning area under the regional development growth rate are shown in table 56.

Table 56 - Projected Average Annual Flood Damages
Regional Development Growth, WRPA 9

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Calcasieu	Upstream Watersheds	1,715	2,024	2,692	3,424
	Principal Streams				
	Headwater Flood	477	554	660	784
	Tidal Flood	2,270	2,522	3,068	3,736
	Total	4,462	5,100	6,420	7,944
Mermentau	Upstream Watersheds	3,152	3,601	4,604	5,460
	Principal Streams				
	Headwater Flood	603	748	862	988
	Tidal Flood	377	437	521	623
	Total	4,132	4,786	5,987	7,071
Bayou Teche-Vermilion	Upstream Watersheds	2,265	2,577	3,279	3,855
	Principal Streams				
	Headwater Flood	68	89	100	117
	Tidal Flood	567	642	761	903
	Total	2,900	3,308	4,140	4,875
Atchafalaya	Upstream Watersheds	1,993	2,268	2,886	3,392
	Principal Streams				
	Headwater Flood	284	433	546	658
	Tidal Flood	78	82	93	106
	Miss. River Flood	64	82	102	147
	Total	2,419	2,865	3,627	4,303
WRPA TOTALS	Upstream Watersheds	9,125	10,470	13,461	16,130
	Principal Streams				
	Headwater Flood	1,432	1,824	2,168	2,547
	Tidal Flood	3,292	3,683	4,443	5,368
	Miss. River Flood	64	82	102	147
	Total	13,913	16,059	20,174	24,193

W R P A 10

W R P A 10

DESCRIPTION

General

WRPA 10 comprises an area of 7,729 square miles in extreme southeastern Louisiana (see figure 29). The Mississippi River bisects, but is not part of the WRPA. The portion east of the Mississippi River is divided by Lake Pontchartrain into areas north and south of the lake. The area north of Lake Pontchartrain is bounded by the Pearl River watershed on the north and east, the Tangipahoa River watershed on the west, and the lake on the south. The area south of Lake Pontchartrain is bounded by Lake Pontchartrain, Lake Borgne, and the Mississippi Sound on the north, the Gulf of Mexico on the east, and the east bank Mississippi River levee and Gulf of Mexico on the west and south. The area west of the Mississippi River lies south of the latitude of White Castle, Louisiana, between the west bank Mississippi River levee and the east Atchafalaya Basin protection levee.

Topography

The terrain in the area located north of Lake Pontchartrain consists of rolling hilly lands and alluvial lowlands with a fringe of tidal marsh along the shoreline of Lake Pontchartrain. In the hill lands elevations vary from about 300 feet[1/] in the headwaters to about 50 feet near Covington, Louisiana. Here the landscape is largely covered by pine forests and the streams are confined in well-defined valleys with steep sides. The alluvial lowlands extend southward from about the latitude of Covington to Lake Pontchartrain. Within the lowlands, tidal marshes and swamps are located adjacent to streams and along the lake's perimeter.

Major streams in the area north of Lake Pontchartrain are the Tchefuncta River and Bogue Falaya. Tchefuncta River rises northwest of the town of Franklinton, and flows generally southward for 70 miles through hills and alluvial lowlands to Lake Pontchartrain. Its major tributary is Bogue Falaya, which enters on the left bank at about mile 11. Streams in the area have narrow sparsely developed floodplains and steep slopes that gradually diminish with the distance downstream until they become tidal in the vicinity of Covington.

The area east of the Mississippi River that is south of Lake Pontchartrain and the area west of the river lie in the deltaic plain

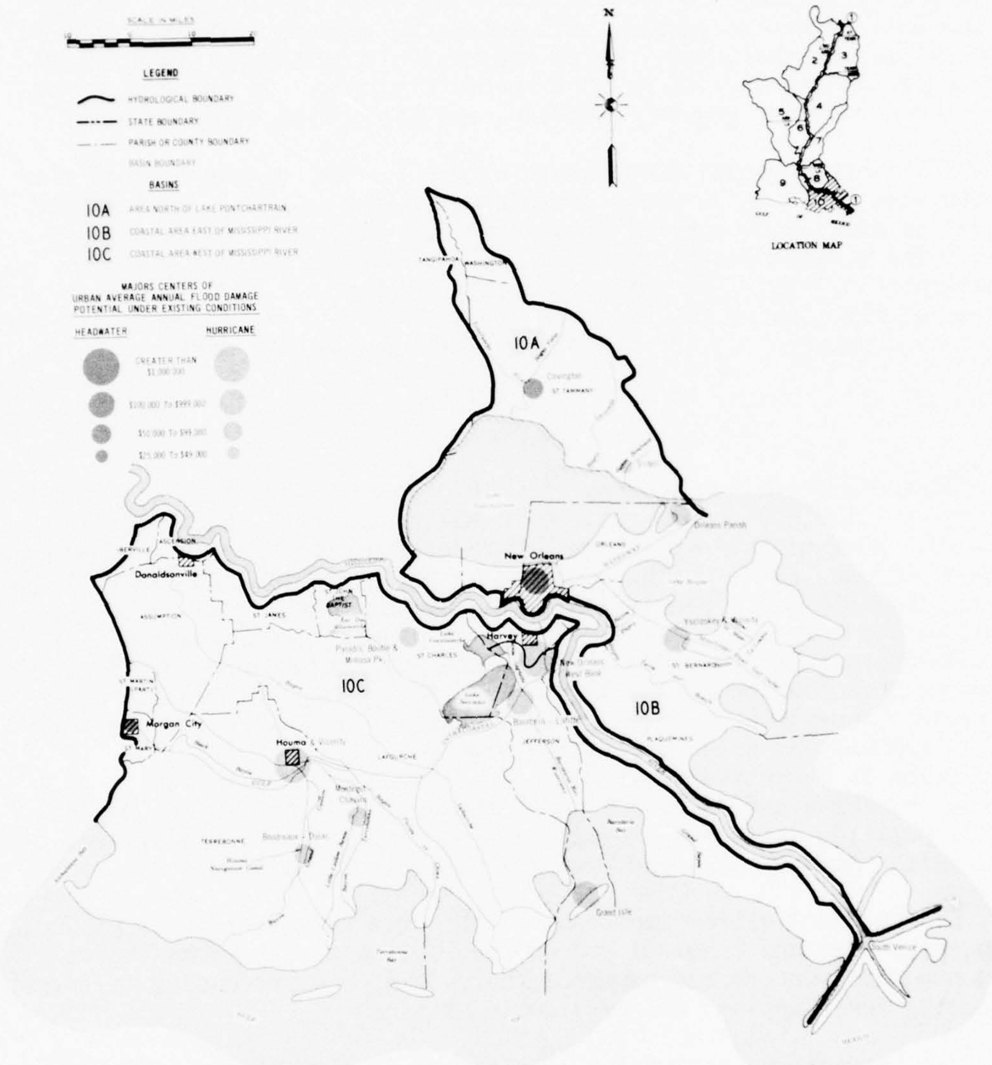
---

1/ All elevations refer to mean sea level unless otherwise specified.

of the Mississippi River. These areas are characterized by a marsh, lake, and bay environment in the lower portion and by a swamp and lake environment in the upper portion. Land elevations range from 0 to 20 feet with the higher lands located along the alluvial ridges of the Mississippi River and Bayou Lafourche. Lesser alluvial ridges exist along numerous smaller streams marking the positions of ancient distributaries of the Mississippi River. Elevations of these lesser natural levee ridges range from 10 feet in the northern part of the area to 1 foot at their gulfward extremities. The areas are packed with a multitude of shallow lakes and bays, interlaced with a labyrinthine network of channels and canals, both natural and man-made.

The area east of the Mississippi River and south of Lake Pontchartrain is drained by outfall canals that discharge directly into Lake Pontchartrain or the marsh.

The area west of the Mississippi River is drained by numerous bayous and man-made canals which include Bayous Lafourche, Verret, Citamon, Chevreuil, and Terrebonne, and the east Atchafalaya Basin protection levee borrow pit. Bayou Lafourche, a tidal stream, formerly a distributary of the Mississippi River, follows a 107-mile course from Donaldsonville, Louisiana, to the Gulf of Mexico. The alluvial ridges adjacent to Bayou Lafourche vary in width from 4 to 8 miles in the upper reaches to about 300 yards in the vicinity of Golden Meadow, Louisiana. Bayous Verret, Citamon, and Chevreuil drain a 15,540-acre area between the Mississippi River and Bayou Lafourche. The streams form a continuous, natural, though choked, major drainage outlet heading near Donaldsonville and extending about 35 miles in a southeasterly direction to Lac Des Allemands. For approximately 10 miles above Lac Des Allemands, Bayou Chevreuil has a well-defined channel upstream from that point. The channel often splits into several lesser channels. Several bayous and former channels, and drainage and logging canals drain into or connect with Bayou Chevreuil, including Bayou Traverse, Coulee Michel, Dredge Boat Canal, and St. James Canal. Bayous Terrebonne, Petit Caillou, Grand Caillou, and Du Large are located west of Bayou Lafourche in the coastal marsh of Terrebonne Parish between the city of Houma and the Gulf of Mexico. These streams are roughly parallel to one another and flow in a southerly direction to either Terrebonne Bay, Caillou Bay, or the Gulf of Mexico. The east Atchafalaya Basin protection levee borrow pit is comprised of several natural watercourses, including lower Grand River, Little Goddel Bayou, Belle River, Bayou Long, and Bayou Milhomme. The borrow pit which originates in WRPA 8 follows a southerly course to Bayou Boeuf and the Gulf Intracoastal Waterway and thence to the Gulf of Mexico via Bayou Chene and the Lower Atchafalaya River near Morgan City.



LOWER MISSISSIPPI REGION
COMPREHENSIVE STUDY

WRPA 10 BASIN MAP WITH URBAN DAMAGE CENTERS

FIGURE 29

Climate

The climate of WRPA 10 is characterized by mild winters, relatively heavy precipitation, and hot summers. The close proximity of the area to the Gulf of Mexico greatly influences the climate, giving it a semi-tropical marine character. Major storms are associated with tropical hurricanes and passage of extra-tropical cyclones. In summer, convective thundershowers generate intense, but highly localized rainfall.

The average annual temperature is 69° F. The average annual precipitation, based on 30 years of record, is 62.6 inches. The maximum annual rainfall recorded was 97.3 inches at Covington, Louisiana, in 1905. The minimum annual rainfall was 31.1 inches at New Orleans, Louisiana, in 1899. The maximum monthly rainfall of 29.0 inches occurred at the town of Belle Chasse, Louisiana, in October 1937. Several stations have reported no rainfall in various calendar months.

Economy

Approximately 21 percent of the 1970 Lower Mississippi Region population or 1,309,000 people resided in the 11 parishes that comprise WRPA 10. Much of the population growth of the area has centered around the New Orleans SMSA, which accounted for 81 percent of the 1970 population. The 1970 urban population, as a percent of the total 1970 population, was 83 percent. Urban centers with populations in excess of 10,000 include Gretna, Harahan, Houma, Jefferson Heights, Kenner, Little Farms, Marrero, Metairie, New Orleans, Slidell, Terrytown, Thibodaux, and Westwego. There are 14 towns with populations between 2,500 and 10,000, and 14 communities with populations between 500 and 2,500. The 2020 population is projected to increase to 2,390,000 under the National Income objective and 2,710,000 under the Regional Development objective. Most population increases are expected to center in the New Orleans SMSA, with the overall trend toward a more urbanized population.

Economic activities important to the area include mineral production, petroleum and chemical processing, agriculture, processing of food products, waterborne commerce, harvesting and processing of forest products, fur trapping, and service industries.

The production, processing, and transportation of minerals has been a major factor in the area's development. Oil, natural gas, salt, sulphur, sand and gravel, and shell are the important minerals produced. The total value of mineral production in 1969 amounted to $2.6 billion. In the future, mineral production is expected to continue as a significant factor in the economy. The projected value of mineral production is expected to almost double by 2020 under the National Income objective and to increase over four and one-half times by 2020 under the Regional Development objective.

Manufacturing is another major factor in the area's economy. A vast complex of petrochemical plants has developed in recent years along the Mississippi River. Other industries have grown up around such native resources as sulphur, salt, and sugar, while imported products such as bauxite, gypsum, and coffee have contributed to industrial development. The 1968 gross product originating from manufacturing industries was about $766 million and is expected to increase to $6.0 billion by 2020 under the National Income objective and to $7.1 billion by 2020 under the Regional Development objective.

Although agriculture is following the national trends of decreasing activity, it still remains economically important. The predominant crop in the area is sugarcane. Other agricultural pursuits include the production of truck crops, citrus fruits, soybeans, and the raising of livestock. Agricultural production sold in 1970 had a value of $36.5 million. In the future, the value of agricultural production is projected to continue to increase to $72 million in 2020 under the National Income objective or $81 million in 2020 under the Regional Development objective.

Present land-use distribution of the 4.9 million acres in WRPA 10 is: 4 percent in cropland; 3 percent in pasture; 27 percent in forest-woodland; 5 percent in urban and built-up land; 23 percent in water areas; 38 percent in other land which consists of farmsteads, idle, etc.; and 1 percent in Federal land. A 59 percent increase in urban and built-up lands is expected by 2020. Decreases are projected in cropland, forest-woodland, and the other land-use categories.

Land transportation in the area is provided by one interstate highway, three Federal highways, numerous State and local roads, and six railways. There are numerous navigable waterways that serve the area, which include the Gulf Intracoastal Waterway, Bayou Barataria Waterway, Bayou Lafourche, Mississippi River-Gulf Outlet, and the Mississippi River. The port of New Orleans, second largest in the Nation, comprises a 50-mile developed water frontage on the Mississippi River and connecting waterways approximately 110 miles above the Gulf of Mexico.

FLOODING IN THE AREA

Types and Characteristics of Flooding

Floods in the area usually result from high tides and excessive precipiation. Most flooding occurs during the late summer, autumn, and spring months, with the duration of flooding varying from a few days to several weeks. Flood occurrences may result from any of the three distinct causes which may occur singly or in combinations. The types of flooding which threaten the area include the following:

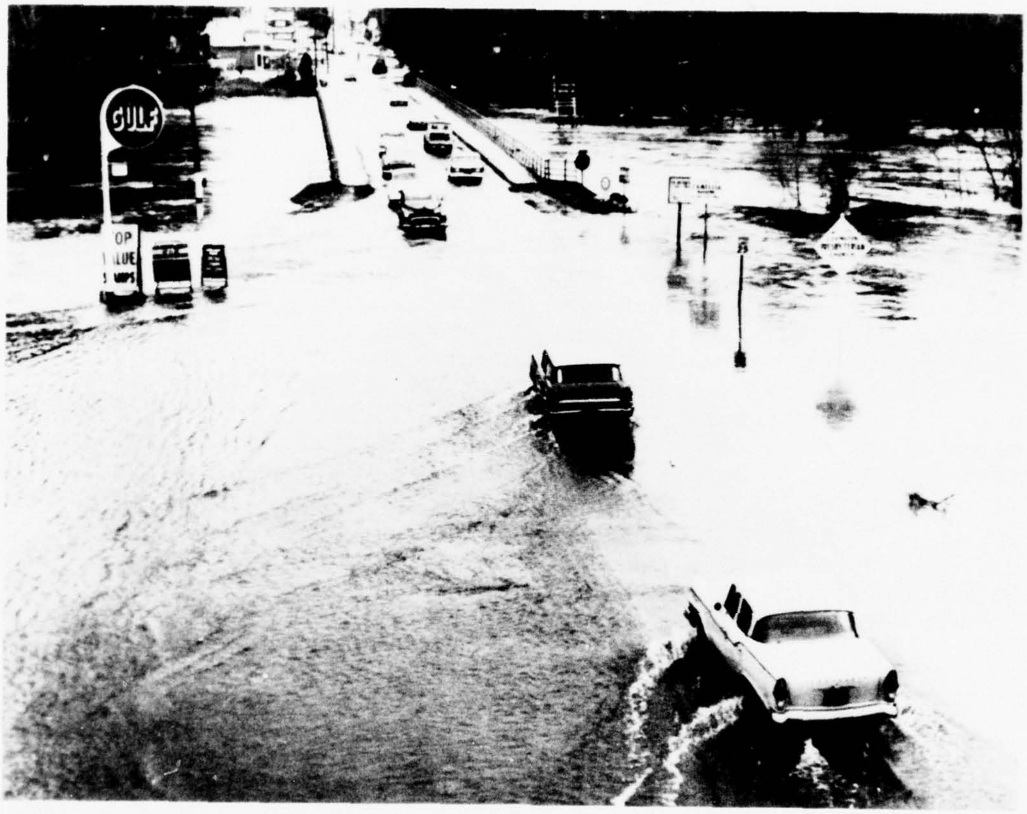
Tidal Flooding

Most of WRPA 10 is subject to overflow by surges associated with tropical storms and hurricanes. Alluvial ridges in the coastal zone are not subject to this type of flooding.

Urban flooding in New Orleans, Louisiana, from Hurricane Betsy, September 1965.

Headwater Flooding

Lands along various drainage arteries are subject to flooding due to high stages in the various streams generated by excessive runoff originating within the watershed tributary to the artery in question.



Flooding along the Bogue Falaya River, February 1961.

Mississippi River Flooding

Lands adjacent to the Mississippi River are subject to flooding due to high stages in the Mississippi River. This type of flooding is generated by runoff which, for all practical purposes, originates outside of the planning area.

Major Historical Floods

General flooding throughout WRPA 10 occurred in 1947, 1956, 1961, 1964, 1965, 1969, and 1973. A description of these significant floods follows.

1947 Flood

The hurricane of 4-21 September, which ranked as one of the greatest of record, produced this flood. It struck the Louisiana coast on 19 September just south of Lake Borgne and moved inland on a westward path just south of Lake Pontchartrain. The entire Gulf Coast in the area experienced a very high tidal surge. Water surface elevations were 11.2 feet on the south shore of Lake Borgne and in Lake Pontchartrain, 6.8 feet at Mandeville, and 5.5 feet at New Orleans. Water flooded over the lakefront seawall at New Orleans, inundating about 8.9 square miles of the area. In Jefferson Parish sheet flow over the low protective embankment along the lakeshore caused flooding of approximately 31 square miles and drainage pumps became inoperative for a considerable period of time. The storm damages in WRPA 10 were estimated at $12,700,000, of which $8,400,000 were caused by tide and waves, $2,900,000 by wind and rainfall, and $1,300,000 were losses from other causes. There were 12 lives lost as a result of the storm.

1956 Flood

Hurricane Flossy during the period 21-30 September was the cause of this flood. The storm crossed the Mississippi River delta on a northeasterly track. Tides reached 5 to 8 feet above the normal along most of the extreme southeastern Louisiana coast. Lake Pontchartrain had tides ranging from 5 to 7 feet. Rainfall during the hurricane was quite heavy. The heaviest occurred at Golden Meadow, where 16.7 inches of rain was recorded. The flood overflowed an area of 2,084,000 acres in the coastal area below New Orleans and around the perimeter of Lake Pontchartrain. Resultant damages were estimated at $15,100,000, of which $9,800,000 were losses caused by tide and waves and $5,300,000 were losses caused by wind and rainfall.

1961 Flood

Hurricane Carla during the period 4-14 September caused this flood. The storm's center moved inland on the central Texas coast; however, because of the storm's circulation enveloping the entire Gulf of Mexico, high tides were experienced along the entire coastline of Louisiana. Tides along the southern coastline of the WRPA were 3 to 4 feet above normal and 4 to 6 feet above normal in Lake Pontchartrain. Rainfall

associated with the hurricane amounted to 4.7 inches at New Orleans during the period 9-14 September and 3.4 inches and 6.2 inches at Houma and Morgan City, respectively. Extensive inundation occurred in the low-lying lands along the coast and around the periphery of Lake Pontchartrain. Approximately 2,200,000 acres in the WRPA were flooded. An estimated $1,400,000 in flood damages resulted in the WRPA from the hurricane, of which $240,000 were crop and $1,160,000 were non-crop.

1964 Flood

The flood of October 1964 was caused by high tides and heavy rainfall produced by Hurricane Hilda during the period 3-5 October. The hurricane moved inland along the western boundary of WRPA 10 and followed an easterly path along the northern boundary. Winds accompanying Hilda caused a tidal build-up of 3 to 4 feet along the Gulf Coast and 4 to 7 feet in Lake Pontchartrain. Along the western and northern boundaries, the storm's rainfall was generally 8 to 9 inches. The rainfall caused streams in the area west of the Mississippi River to rise above flood stage. However, most of the inundation was the result of tidal overflow. Approximately 2,349,000 acres were flooded by tidal surges, while headwater flooding occurred on 311,000 acres. Damage resulting from tidal flooding was $5,300,000, and headwater flooding resulted in damages of $46,000.

1965 Flood

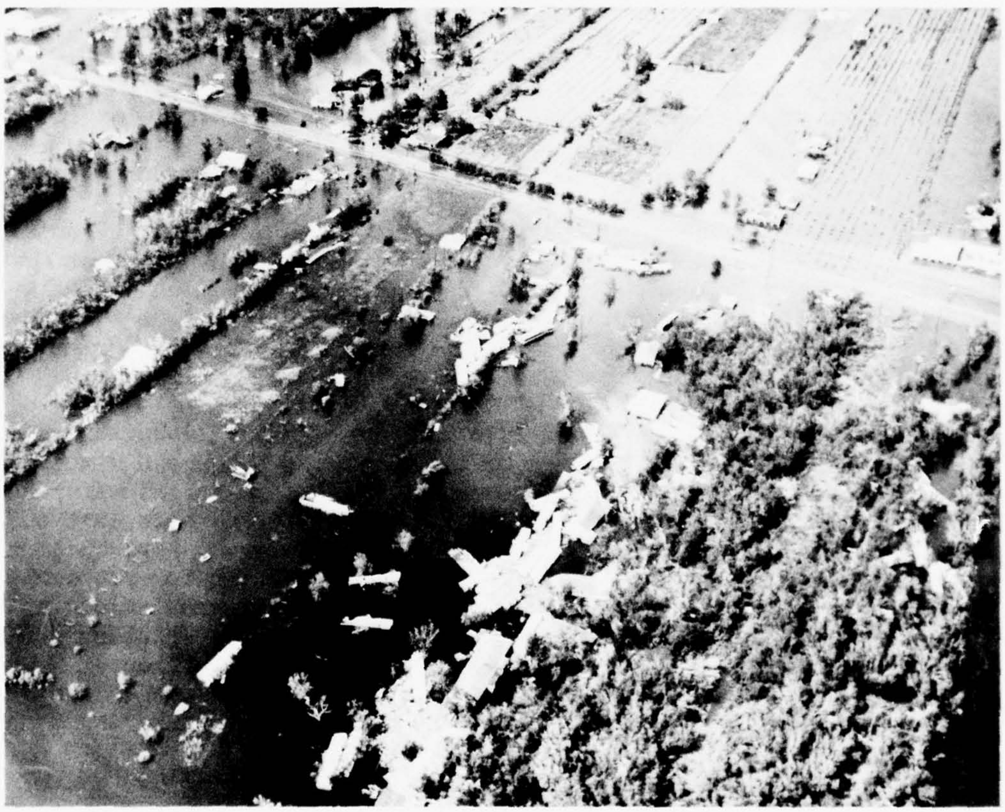
This flood was caused by Hurricane Betsy which reached the Louisiana coast on 9 September. Betsy moved onto the Louisiana coast at Grand Isle with winds up to 160 m.p.h. and 125 m.p.h. at New Orleans. Rainfall associated with the hurricane ranged generally from 4 to 6 inches throughout the area during the storm. Flooding, however, was primarily the result of storm tides.

Storm tides swept over Grand Isle and practically all buildings were destroyed or severely damaged by the onrushing surge and waves. Just to the east of Grand Isle, a combination of storm surges entering the Mississippi River from the south and east overtopped both east and west river levees, inundating the Venice-Buras-Empire and Port Sulphur area with water depths up to 11.5 feet. The storm surges overtopped the back levee in the Bohemia-Point a la Hache-Phoenix area, flooding and heavily damaging all structures located in the area. Farther north, practically all communities were flooded. The eastern portion of New Orleans and the adjacent Chalmette area suffered severe damage from floodwaters and winds. In these areas the depth of flooding ranged up to 9 feet.

Approximately 2,400,000 acres in the WRPA were flooded. The flooding resulted in $162,900,000 in non-crop damages, and $6,700,000 in crop damages. In addition, inseparable damages resulting from wind and water were $144,300,000. The hurricane was responsible for 81 deaths in the area.

1969 Flood

Hurricane Camille, which sideswiped the mouth of the Mississippi River and touched land in the Waveland-Bay St. Louis, Mississippi, area on 17 August, produced this flood. Winds estimated at 160 m.p.h. and tides of 22 to 23 feet above normal accompanied the hurricane. In WRPA 10 winds ranged from 60 m.p.h. at New Orleans to 160 m.p.h. at the mouth of the Mississippi River, and tides ranged from 5.2 feet above normal at New Orleans to 11.1 feet above normal at Shell Beach. There was very little rainfall associated with Camille, with 1.7 inches recorded at New Orleans and 5.0 inches recorded at Slidell. The hurricane inundated some 860,000 acres in the WRPA and caused damages in the flooded area to crops of \$2,900,000 and \$195,800,000 to non-crop. It is estimated that about 90 percent of the damages were the result of tidal overflow, while the remaining 10 percent were the result of winds.



Tidal flood damage from Hurricane Camille in August 1969.

1973 Flood

WRPA 10 experienced severe flooding in 1973. Critical flood stages on the Mississippi River dictated the opening of the Bonnet Carre Spillway. The Bonnet Carre was open from April 11 to June 21 and dramatically served its purpose of protecting New Orleans. In addition, throughout the spring, prevailing winds from the south created abnormally high flood stages along the Gulf Coast. Heavy spring rains aggravated the situation and caused many low-lying areas adjacent to the marsh to become inundated.

Flooding in the area west of the Mississippi originated from several causes. Below U. S. Highway 90, tidal flooding inundated all areas except the alluvial ridges of the Mississippi River, Bayou Lafourche, and the many smaller streams that drain into the Gulf. The area above U. S. Highway 90 was inundated by a combination of causes including frequent and hard rains and inadequate runoff. Heavy damage to residential, commercial, and industrial development resulted from the high water. Morgan City suffered devastating losses both within and outside of its protected area. Several thousand people evacuated the Morgan City area because of the flood threat. Another 800 people were forced to evacuate their homes in the Lake Verret area. Residential and industrial areas were also flooded in Jefferson Parish. Agricultural losses were heaviest to sugar cane, pasture and livestock.

Inundation east of the Mississippi and south of Lake Pontchartrain was generally caused by tidal flooding. Damages throughout this part of WRPA 10 were relatively light with only minor damages to developed areas and pasture.

The area north of Lake Pontchartrain had very little flooding and only nominal damages. Low-lying areas east of Mandeville and several hundred acres of pasture were affected.

The 1973 Flood had a severe impact on WRPA 10. Total acreage inundated in WRPA 10 was 2,445,000 acres, comprised of 1,750,000 acres of tidal flooding and 695,000 acres flooded from headwater and other causes. Losses from the flooding amounted to $24.0 million.

Existing Flood Damage Prevention Program

Structural Program

In cooperation with local interests, the Federal Government has constructed flood control improvements that give partial protection from headwater, tidal, and Mississippi River floods. A summary of these improvements is given below and in table 57. Detailed information on the improvements is contained in the Inventory of Facilities Appendix. Information on projects and studies underway and Federal agency authorities are contained in Appendix T, Plan Formulation.

Protection from Mississippi River overflow is afforded the WRPA by flood control works that are an integral part of the regional flood control program for the Mississippi River and its tributaries. In the WRPA, flood control works that prevent Mississippi River overflow include a levee system on the east and west banks of the Mississippi River, the Bonnet Carré Floodway which allows diversion of floodwaters to the Gulf of Mexico via Lake Pontchartrain, levees along the shore of Lake Pontchartrain in the vicinity of New Orleans, and the east guide levee of the Atchafalaya Basin Floodway which confines floodwaters diverted to the Atchafalaya Floodway. The program to control floods on the Mississippi River is under construction, and until the entire program is completed, the flood control plan will be only partially effective.

Mississippi River levee in vicinity of New Orleans, Louisiana, preventing overflow from 1950 highwater.

In the area west of the Mississippi River, natural drainage intercepted by construction of the east protection levee of the Atchafalaya Floodway has been provided by excavation of landside borrow pit drainage channels where necessary to provide a continuous artery east of the levee throughout its length. Other flood control measures in this area which reduce headwater flood damages have been provided on Bayou L' Eau Bleu, Baker Canal, and Bayou Folse. Protection against tidal flooding is now under construction or authorized for the developed areas located along the west bank of the Mississippi River between City Price and Venice, both banks of Bayou Lafourche between Golden Meadow and Larose, and the Morgan City area.

In the area east of the Mississippi River, hurricane protection measures are under construction to prevent tidal flooding in the New Orleans metropolitan area and other areas bordering on Lake Pontchartrain and the developed area along the east bank of the Mississippi River between Phoenix and Bohemia. Channel improvements on Bayou Vincent reduce headwater flood damages in the bayou's tributary watershed.

Bonnet Carré Spillway, upstream from New Orleans, diverts Mississippi River floodwaters into Lake Pontchartrain to prevent levee overtopping downstream.

Local interests have constructed a number of improvements that provide land drainage and protection against flooding.

Table 57 - Summary of Local Protection Projects, 1970, WRPA 10 1/

Drainage Area	Levees (Miles)	Channel Improvement (Miles)	Pumping Plants (No.)	Pumping Plants (Total c.f.s.)
Area north of Lake Pontchartrain	-	2	-	-
Coastal area east of Mississippi River	205	-	-	-
Coastal area west of Mississippi River	309 2/	70	1	154
Total	514	72	1	154

1/ Consists of projects in both upstream watersheds and principal reaches, excluding improvements by local interests.

2/ Excludes east guide levee of Atchafalaya Basin Floodway.

Land Treatment

Over 1.8 million acres in the WRPA are adequately treated to reduce erosion and sedimentation and assist in the reduction of surface runoff. Table 58 presents data on acres receiving adequate treatment by drainage areas.

Table 58 - Land Treatment, 1970, WRPA 10

Drainage Area	Lands Adequately Treated Acres (1,000's)
Area north of Lake Pontchartrain	179
Coastal area east of Mississippi River	321
Coastal area west of Mississippi River	1,323
Total	1,823

Major floods in the area north of Lake Pontchartrain would result mostly in damages to urban and built-up areas. Two urban places that would sustain heavy damages from major floods are Covington and Slidell. Other improvements subject to flooding by a major flood include highway and railroad transportation facilities and crop and pasture lands.

Remaining damages in the coastal area east of the Mississippi River largely consist of tidal-induced damages to facilities of the petroleum and fishing industries and developed areas between the St. Bernard-Plaquemines Parish line and Phoenix, Louisiana, and below Bohemia, Louisiana. Headwater flood damages occur principally on crop and pasture lands.

In the area west of the Mississippi River, the remaining damages occur primarily as the result of tidal flooding in urban and built-up areas which include the towns of Barataria and Lafitte, communities surrounding Houma, and parts of the New Orleans SMSA. The headwater flood damages are rural in nature and primarily result in damages to the agricultural industry.

Table 59 summarizes the area subject to flooding and average annual damages in upstream watersheds and principal reach areas by Standard Project Floods and Standard Project Hurricanes under existing development conditions. The data presented in this tabulation are based on the assumption that all projects now under construction are completed. In the area where major projects are under construction, however, additional lands are still subject to flooding and damages of disastrous proportions could occur without completion of the projects. These damages and acreages are in addition to those presented in table 59.

Table 59 - Remaining Flood Problems, Existing Conditions, WRPA 10

Basin	Area Subject to Floods (1,000 Acres)		Average Annual Damages ($1,000) Damages Due to Flooding											
			Principal Streams				Upstream Watersheds				Total			
	Principal Streams	Upstream Watersheds	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total	Agricultural	Urban & Built-up	Other	Total
Area north of Lake Pontchartrain														
Headwater Flood	-	64	-	-	-	-	54	637	141	832	54	637	141	832
Tidal Flood	-	-	1	259	3	263	-	-	-	-	1	259	3	263
Coastal area east of Mississippi R.														
Headwater Flood	-	305	-	-	-	-	364	-	-	364	364	-	-	364
Tidal Flood	362	-	111	2,070	380	2,561	-	-	-	-	111	2,070	380	2,561
Coastal area west of Mississippi R.														
Headwater Flood	252	2,252	15	39	3	57	4,100	-	-	4,100	4,115	39	3	4,157
Tidal Flood	1,892	-	250	18,910	2,254	21,414	-	-	-	-	250	18,910	2,254	21,414
TOTALS														
Headwater Flood	252	2,621	15	39	3	57	4,518	637	141	5,296	4,533	676	144	5,353
Tidal Flood	2,254	-	362	21,239	2,637	24,238	-	-	-	-	362	21,239	2,637	24,238
TOTAL						24,295				5,296				29,591

Nonstructural Program

Two Flood Plain Information reports have been completed or are underway in WRPA 10. These reports present a record of the largest known historical floods and delineate the area that may be inundated by probable future floods. Fourteen flood insurance studies have been completed or are underway in the WRPA.

Flood Forecasting

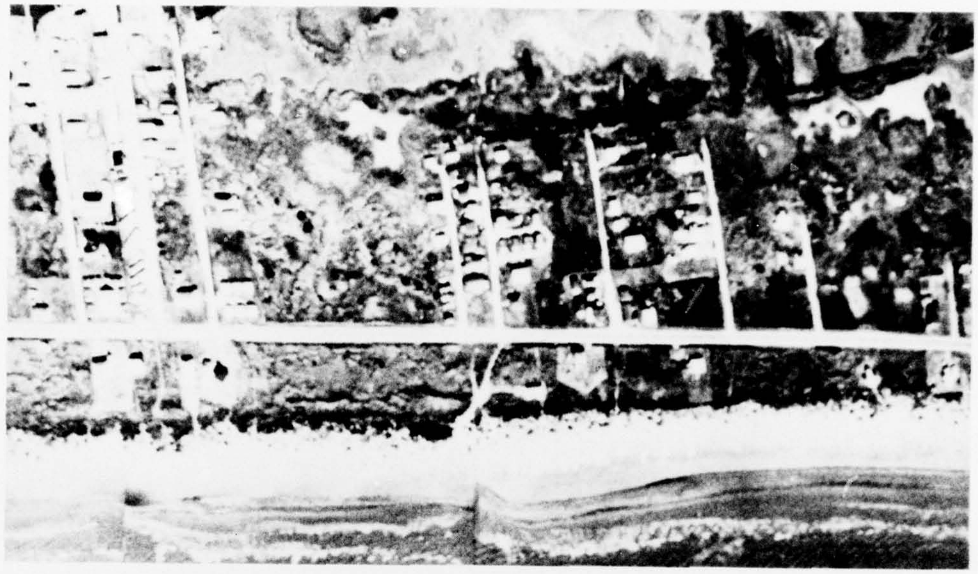
Hurricane, river, and flood forecasts and warnings are issued by the National Weather Service. Forecast dissemination is largely provided by news media through the use of the NOAA Weather Wire Service, a teletypewriter network available to all bona fide mass news disseminators.

Emergency Operations

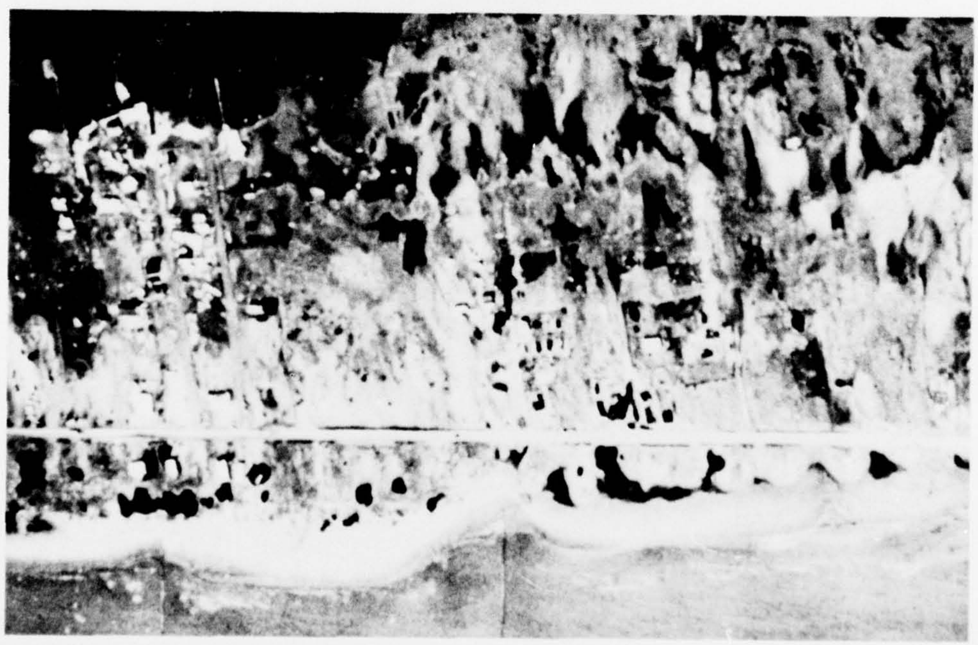
On numerous occasions when natural disasters such as flood and hurricanes have befallen the area, the Federal Government, State, and local agencies have cooperated in performing emergency operations. Emergency operations performed in the past have included evacuation and assistance to reduce loss of life in threatened areas, flood fighting to reduce damages, and recovery operations.

Remaining Flood Problems

The major flood problems remaining in WRPA 10 are the results of inundation from tides caused by hurricanes and headwater flooding. Mississippi River flooding will be for the most part controlled when the Mississippi River and Tributaries project is completed. Approximately 2.3 million acres are subject to flooding by Standard Project Hurricanes with existing projects in place. Standard Project Floods would result in flooding of about 252,000 areas in the principal reaches, with projects in place, and 2.6 million acres in the upstream watersheds. Most of the area remaining that is subject to flooding is west of the Mississippi River. Since flooding may result from more than one cause, the acreage subject to flooding stated above by each cause is not additive. Urban and built-up places with average annual damages greater than $25,000 are shown in figure 29.



Before Hurricane "Betsy" Grand Isle, Louisiana, 7 October 1965.



After Hurricane "Betsy" Grand Isle, Louisiana, 8 October 1965.

FUTURE DAMAGES

General

Future flood damages are evaluated for two objectives, National Income and Regional Development. The objectives differ in that the National Income objective is based on the level of economic activity indicated by OBERS projections whereas the Regional Development objective is based on the level of economic development that would improve the comparative advantage of the region's industry and utilize more fully the available resources.

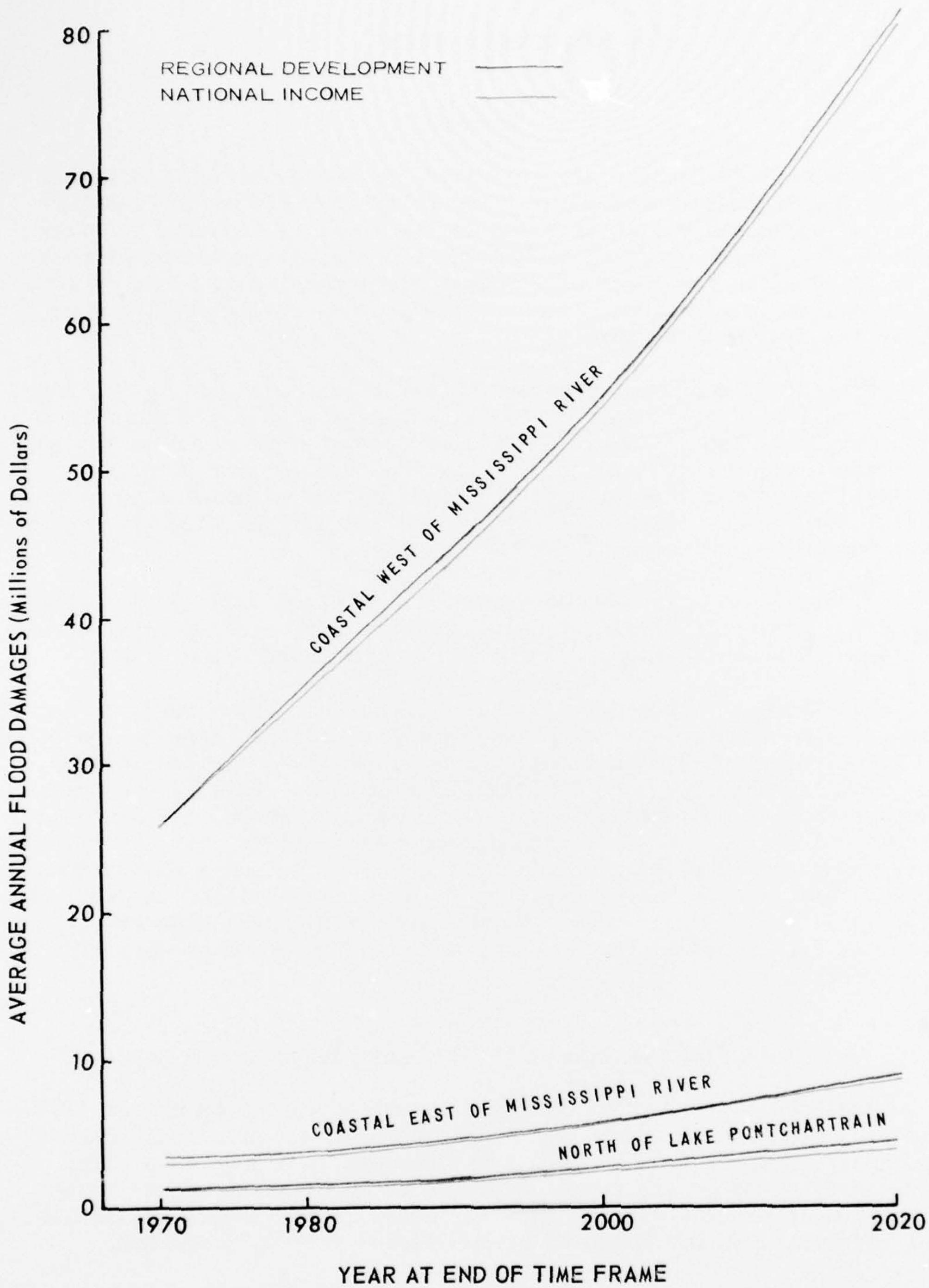
Projected land-use trends indicate further urban and agricultural development will take place in the floodplains. Further expansion of urban areas in the flood-prone areas is estimated to be about the same under both the National Income and Regional Development objectives. However, urban development under the Regional Development objective is expected to be denser and agricultural yields will be slightly higher as compared to the National Income objective.

Figure 30 illustrates the trends and relative magnitudes of future damages. The distribution of damages by type for each of the two objectives is shown in figure 31 for the 1970 and 2020 time frame.

The level of flood damages that could result from Standard Project Floods, Standard Project Hurricanes, and Mississippi River Design Floods in principal reaches is estimated to be about \$34.4 million in 1980, \$53.6 million in 2000, and \$82.3 million in 2020. This is the maximum flood potential and does not vary significantly between the National Income and Regional Development objective projections. In the upstream watersheds the level of flood damages is estimated under the National Income objective to be \$6.4 million in 1980, \$8.3 million in 2000, and \$10.5 million in 2020. Under the Regional Development objective, the level of flood damages in the upstream watershed would be approximately 1 percent higher.

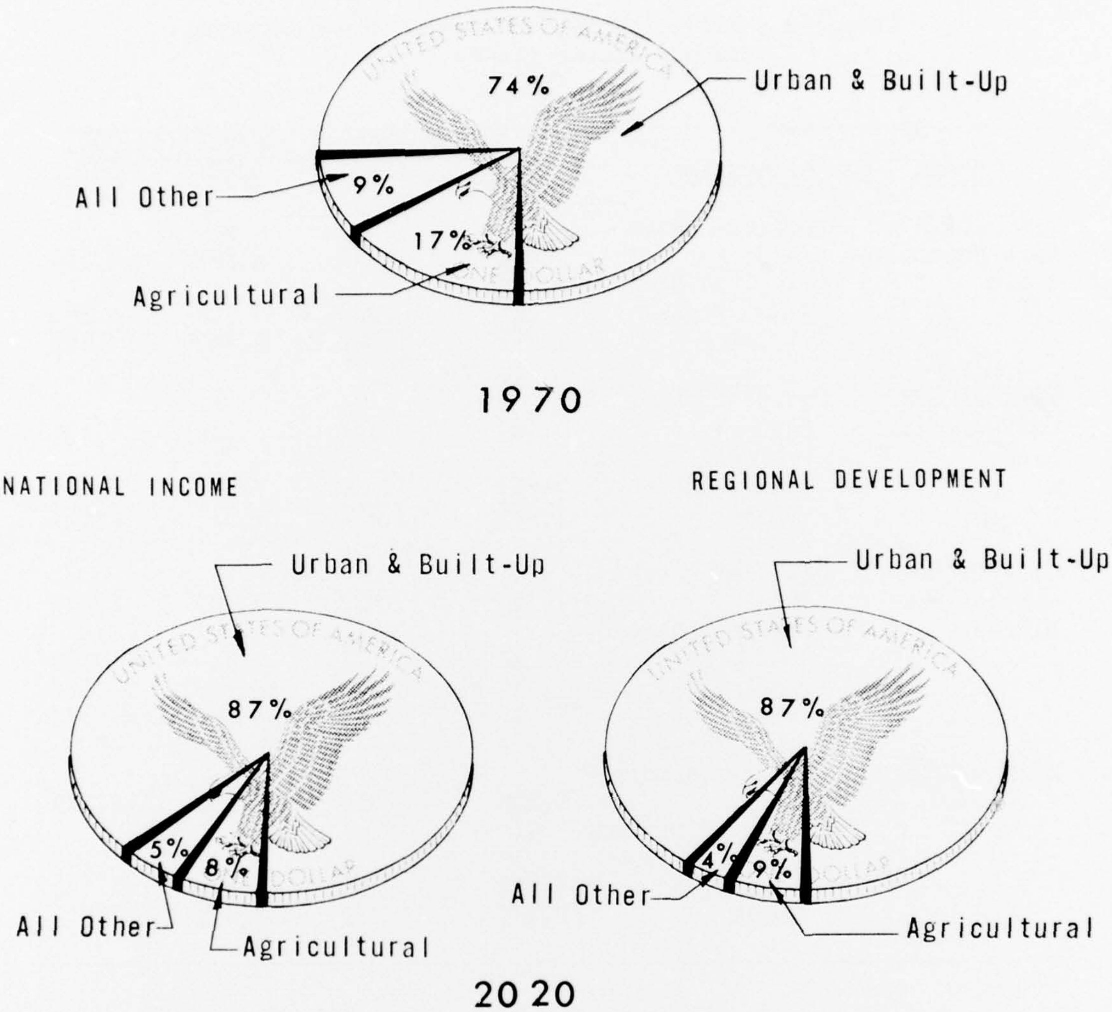
Future Flood Damages with National Income Growth Rate

Table 60 lists for the National Income objective base year (1970) the projected levels of average annual damages for principal reaches and upstream watersheds by principal drainage area and cause. The effects of flood control works expected to be existing or under construction in fiscal year 1973 are reflected in the projected damages, but effects of future measures beyond fiscal year 1973 are not.



PROJECTED AVERAGE ANNUAL DAMAGES - WRPA-10

Figure 30



DISTRIBUTION OF ANNUAL FLOOD DAMAGE

WRPA-10

Figure 31

Table 60 - Projected Average Annual Flood Damages, National Income Growth, WRPA 10

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Area north of Lake Pontchar- train	Upstream Water- sheds	832	1,092	1,889	3,234
	Principal Streams				
	Tidal Flood	263	336	528	861
	TOTAL	1,095	1,428	2,417	4,095
Coastal area east of Miss. River	Upstream Water- sheds	364	428	522	596
	Principal Streams				
	Tidal Flood	2,561	3,131	4,790	7,755
	TOTAL	2,925	3,559	5,312	8,351
Coastal area west of Miss. River	Upstream Water- sheds	4,100	4,830	5,883	6,715
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	21,414	30,848	48,165	73,550
	TOTAL	25,571	35,753	54,166	80,433
WRPA TOTALS	Upstream Water- sheds	5,296	6,350	8,294	10,545
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	24,238	34,315	53,483	82,166
	TOTAL	29,591	40,740	61,895	92,879

Future Flood Damages with Regional Development Growth Rate

Estimated future flood damages under the Regional Development objective will be of the same type and magnitude as those estimated for the National Income objective and are presented in table 61.

Table 61 - Projected Average Annual Flood Damages
Regional Development Growth, WRPA 10

Basin	Delineation	Average Annual Damages ($1,000) 1970	1980	2000	2020
Area north of Lake Pontchar-train	Upstream Water-sheds	832	1,105	1,953	3,352
	Principal Streams				
	Tidal Flood	263	336	528	861
	TOTAL	1,095	1,441	2,481	4,213
Coastal area east of Miss. River	Upstream Water-sheds	364	428	555	631
	Principal Streams				
	Tidal Flood	2,561	3,131	4,790	7,755
	TOTAL	2,925	3,559	5,345	8,386
Coastal area west of Miss. River	Upstream Water-sheds	4,100	4,829	6,256	7,117
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	21,414	30,848	48,165	73,550
	TOTAL	25,571	35,752	54,539	80,835
WRPA TOTALS	Upstream Water-sheds	5,296	6,362	8,764	11,100
	Principal Streams				
	Headwater Flood	57	75	118	168
	Tidal Flood	24,238	34,315	53,483	82,166
	TOTAL	29,591	40,752	62,365	93,434

METHODOLOGY

M E T H O D O L O G Y

Present and projected flood problems were delineated by principal streams and upstream watersheds. A stream or flood plain area was included under the designation "principal streams" if it met one or more of the following conditions:

a. The drainage basin above the upper limit of the stream reach was 250,000 acres or more.

b. The stream reach was within the overflow area of streams within the Mississippi River and Tributaries project boundaries, or reasonable extensions of those tributary streams serving as major outlets for upstream watersheds.

c. Areas subject to tidal overflow.

d. Areas involving urban flood problems with populations in excess of 2,500.

Upstream watersheds generally consist of watersheds that contain 250,000 acres or less and are delineated using guidelines used to appraise watersheds under the Watershed Protection and Flood Prevention Act (Public Law 566, as amended). During the revision by the Soil Conservation Service of its watershed projects inventory, all basins and subbasins, as shown in the "Atlas of River Basins of the United States," were delineated to identify small watersheds. These small watershed delineations, with few exceptions, were used for this study.

The remaining flood problems in the Lower Mississippi Region are defined as the area subject to flooding and the average annual flood damage under existing conditions. Existing conditions are defined as the basin-stream hydrologic and hydraulic characteristics with all existing projects in place. Existing projects are defined as those completed or under construction as of 30 June 1973. An exception was made in the case of long term continuing construction projects which are not now nor soon to be completed. On these long-term projects, that portion of the project which will be completed prior to 1980 was assumed to be in place in defining the 1970 remaining flood problems.

Acres subject to flooding were assessed by a determination of the area within the outline of a large flood on each particular stream. The "large" flood was a Standard Project Flood (SPF) estimate, a 100-year frequency flood, or the flood of record (major historical flood), whichever was available. If none of these flood outlines were available, an SPF estimate was developed, its outline placed on a map, and the area subject to that flood measured. The SPF is a flood which would result from occurrence of a Standard Project Storm, which is de-

fined as the most severe flood-producing rainfall depth-area-duration relationship and isohyetal pattern of any storm that is considered reasonably characteristic of the region in which a particular drainage basin is located. Tidal flooding was estimated on the basis of a Standard Project Hurricane, which has a similar definition. Areas subject to flooding were grouped by source of flooding as headwater, backwater, or tidal flooding. The acreages flooded from these three classifications are not additive as some of the area flooded by tidal flooding is also flooded at times by headwater flooding, etc. However, damages from these three types of flooding were calculated for each type of flood and are additive.

Flood damages (shown as average Annual Damages) were assessed for the present (1970) and under the two alternative futures - Program A and Program B, reflecting growth of several economic parameters as defined in the Economics Appendix. Program A economic growth is that adopted for the National Income Objective and the Program B economic growth is that adopted for the Regional Development Objective. Average Annual Damage is the expression of damage values as a uniform annual series that considers the nonuniform rate of damage accrual. Each yearly damage is reduced to its present worth, and the sum of these present worths is spread uniformly over the period of analysis. The average annual damages in this appendix relect conditions of development or agricultural activity at the specified time the damage figure is shown. Current (1970) damages reflect average annual damages which would occur over a long period of time with no change in development or agricultural activity in the future; the 1980 average annual damages are those which would occur over a long period of time with expected 1980 levels of development and agricultural activity with no change in those levels in future years, and so on.

Current (1970) damages were taken where possible from more detailed recent studies and reports. Flood damage data was applied to other watersheds and principal streams when it was determined that common development and flooding characteristics existed. Where little or no data were available, hydrologic and hydraulic characteristics were determined, field reconnaissance was done to obtain a cursory valuation of develoments in urban flood plains, topographic maps showing cleared, wooded, and water areas were consulted, and damage for each of several levels of flooding was estimated. The frequency of those levels of flooding was combined with the related damage to establish frequency damage curves. The area under the curve yields average annual damages. For agricultural areas the damages are composed of damages to crops and other farm improvements, including farm residences, outbuildings, etc. The prices used to assess the agricultural damages were adjusted normalized prices which are normalized current prices adjusted to remove influences of government support prices and/or acreage limitations, etc. Normalized current prices are prices for the latest year on which data were available (1969 in this case) prior to the year of use (most of the

agricultural damage calculations were done 1970-71), and normalized by the use of trend lines developed from recent historical prices in order to eliminate short term fluctuations due to bad weather, floods, etc., which otherwise would tend to increase prices because of speculation on possible resultant shortages. These do not reflect the major price increases of agricultural products which have occurred since 1970. Were the current prices (1974) or even an average of the prices since 1970 used in lieu of adjusted normalized prices, the agricultural average annual damages would be substantially greater than those shown in this appendix. All damage assessments, both current and future, are expressed in terms of 1970 dollars.

Future damages for both the Program A and Program B futures were assessed in the same manner as current damages except that growth in crop yields and the urban related economy and expected changes in land use in the flood plain were accounted for.

In rural agricultural flood plain areas expected changes in land use over time were developed by the Land Use Subcommittee. This was done because future changes in land use are a necessary ingredient in the determination of future damages for rural areas. The changes, along with the projected increases in crop yields, accounted for the increases in agricultural damages over the study time frame. Most of the increase in agricultural damage was due to increased yields. Subsequent to incorporation of the projected land use data into flood problem identification, a general land use plan for future years was developed as a part of plan formulation (see Appendix T). The formulated land use plan and the projected land use provided for flood problem identification purposes were compared and found to be in close agreement. The projected land use had a slightly slower rate of change from wooded to cleared than the formulated plan. The formulated land use plan was not used in determining future flood damages because the timing of study accomplishment required early completion of the water damage assessment and the land use plan was not finalized until the overall study was near to completion. Also the land use plan was formulated on a whole WRPA basis while the land use projections were developed for specific, smaller river basins and were for flood plains only.

In urban areas, increases in damage over time were estimated by the most appropriate one of several methods for each respective urban area. Where trends in growth of development in flood plains were established and no effective flood-plain management program adopted for a given city, probable geographical growth was placed on topographical maps and damages estimated then in the same manner as the current condition damages were. In other cases, per capita income growth factors, population growth factors, and industrial growth factors were applied to the 1970 damage estimates singly or in some combination as judged appropriate on a city-by-city basis in order to arrive at an estimate of future damages.

The term "land treatment" is frequently used in this appendix, and the acreage of lands adequately treated is given mainly, because land treatment and management often reduces peak flows and has a beneficial effect on flooding. Land treatment and management measures are defined as a tillage practice, a pattern of tillage or land use or land management facility improvements to alter runoff, reduce sediment production, improve use of drainage and irrigation facilities, or improve plant or animal production.

WATER
RESOURCES
PLANNING
AREAS
1
2
3
4
5
6
7
8
8
9
10
10
MO.
ARK.
KY.
TENN.
TENN.
MISS.
ARK.
LA.
MISS.
LA.